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Three Essays in Public Finance

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Three Essays in Public Finance

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DISSERTATION

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

THE UNIVERSITY OF TEXAS AT AUSTIN

August 2009

Dedicated to

my wife Sibel,

my son Ercument and

my parents Mahmut and Turkan.

Acknowledgments

I would like to thank my thesis supervisors Roberton Williams for his generous time and encouragement. I am also very grateful for having an exceptional doctoral committee. I want to thank to my committee members Daniel S. Hamermesh, Jason I. Abrevaya and Lillian Mills for their support and fruitful conversations.

My special thanks go to my wife Sibel for her enormous support, understanding and patience. I would also like to thank to my parents for their continuous support through my entire life. My mom used to dream of having a child with a doctorate degree. I am very happy that her dream came true. My dad valued education a lot and has done so much for us to get good education. I thank him so much for being such a great dad.

Three Essays in Public Finance

Publication No. ____________________

Abdulkadir Nagac, Ph.D.
The University of Texas at Austin, 2009

Supervisor: Roberton Williams

Taxes are major source of public funds to finance government expenditures. Tax authorities impose different kind of taxes and employ many agents to collect taxes effectively. Some dutiful taxpayers will undoubtedly pay their tax liabilities while many others will not. The Internal Revenue Service in the United States reports that the estimate of income tax liability not collected is about 17, which translates into 345 billion for 2001. It is important to make a distinction between tax evasion and tax avoidance. The distinguishing characteristic of evasion is illegality. Whether the reason for not paying tax liability is avoidance or evasion, economic models of taxation need to be changed in the light of these realities. In this study, I analyze some of the economic problems of tax evasion/avoidance.

In the first chapter, I discuss the relationship between number of tax audits, tax administration reform and tax compliance in Turkey. In recent years, many developing countries have carried out reforms in their tax administration to increase their efficiency in collecting taxes. In 2005, the tax authority in Turkey established Tax Office Directorates (T.O.D.s) in 29 provinces for the purpose of controlling

the underground economy, improving taxpayer assistance, and increasing auditing efficiency. By using the panel data on province level tax returns, my analysis answers two questions. First, I examine the effect of audits on reported income and reported tax liability. By controlling for the detectibility of evasion and other socioeconomic variables, I find that audits have the same effectiveness in increasing reported income and reported tax liability. Second, I investigate the effect of establishing T.O.D.s in 29 provinces on compliance in those provinces. I find that T.O.D.s are effective at the extensive margin rather than the intensive margin. Thus, establishing T.O.D.s had no significant effect on the compliance level of existing taxpayers while it increased the number of tax returns significantly.

In the second chapter, I analyze the excess burden on income tax when tax avoidance matters. I present a simple static labor supply model with endogenous asset choice. Then, I examine how tax avoidance through asset trading affects the labor supply response and the excess burden of income tax. Furthermore, I discuss the implications of the tax policy analysis and show that a failure to account for avoidance responses may lead to errors when estimating how tax reform affects labor supply, tax revenue, and the welfare cost of taxation. Because of tax avoidance through tax arbitrage, the progressivity of a given tax system will be less than what the formal tax system implies.

In the third chapter,we study the Marginal Cost of Funds in the existence of tax evasion. We develop a general equilibrium model of tax evasion, including the expected utility of taxpayers and three different revenue-raising government policies. In this rich model environment, we analytically derive the marginal cost of funds

(MCF) for the alternative policy instruments. We consider two main fiscal reforms: the revision in the nonlinear tax scheme and the changes in enforcement mechanism (the audit and penalty rates). First, we derive the MCF for the tax reform and find its key determinants. The derived MCF is greater than the previous ones since it includes a "risk-bearing cost" as well as tax distortion. The reform in enforcement mechanism generates MCFs in different forms. Two more MCFs with respect to audit and penalty rates are presented. Finally, we compare these three different MCFs in numerical example and provide some policy implications.

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Chapter 1

Tax Arbitrage and Excess Burden of Income Tax

1.1 Introduction

How labor supply responds to taxation is one of the most intensively researched issues in public finance literature. A large number of studies have explored various dimensions of labor supply choice and how tax reform affects hours supply. Efficiency loss caused by the distortionary tax has also been the interest of economists. In standard models the efficiency cost of taxation is entirely due to the fact that, due of the change in relative prices, individuals are induced to select socially suboptimal consumption baskets – to substitute away from relatively highly-taxed goods to relatively lightly-taxed goods, such as leisure. A standard exercise in optimal taxation theory is to describe the tax system that minimizes these costs, or to describe the tradeoff between these costs and the distribution of welfare in the society. However, as a response to taxation, individuals do not only change their consumption baskets but also may change their asset portfolio. Most of the labor supply and optimal taxation literature abstracts from issues of tax planning and tax arbitrage.

Hausman (1981), MaCurdy, Green and Paarsch (1990), and Blomquist (1996) are among the prominent econometric analysis of labor supply which assume an individual's asset income is exogenous and determined independently of the supply of hours. The positive analysis of how tax changes affect labor supply implicitly assumes that the effective marginal tax rate changes in tandem with the statutory marginal tax rate. The normative analysis of income taxation following Mirrlees (1971) rests on the assumption that the optimal income tax schedule is some non-linear function applied to true labor income. However, when tax avoidance through asset trading is an option, labor supply predictions and the efficiency cost of tax will be different than what traditional analysis predict. Taxation will induce some people to choose a sub-optimal asset portfolio. Therefore, it is necessary to take individuals' portfolio choices into account in order to correctly estimate the labor supply response and the deadweight loss of an income tax.

My purpose in this paper is to explore the excess burden of income tax and labor supply behavior when individuals engage in tax avoidance. I set up a static labor supply model where individuals decide how much to work and how much to avoid taxes. Then, I analyze how big the labor supply response and the excess burden of income tax are in comparison to standard models. Tax avoidance can broadly be defined as one's efforts and activities to reduce one's tax liability. One example is to pay a tax professional to alert one to the tax deductibility of activities already undertaken. Another example is to change the legal form of a given behavior, such as reorganizing a business from a C corporation to an S corporation, re-characterizing ordinary income as capital gain, or renaming a consumer loan as a home equity loan. A third example is tax arbitrage, when economically equivalent, but differentially-taxed, positions are held simultaneously long and short, thereby producing tax savings. Finally, re-timing a transaction to alter the tax year it falls under is another example of avoidance. In this study, I focus on tax arbitrage as a method of reducing one's tax liability. In their empirical study, Altshuler and Gentry (1995) show the prevalence of tax arbitrage behavior in the U.S. economy. They show that in the group of tax returns with only mortgage interest deductions, 20 percent of returns receive tax-exempt interest, 46 percent receive retirement contributions, and 25 percent receive capital gains. They conclude that instead of reducing the principal of their mortgages as a means of saving through house equity, some taxpayers choose to buy tax-exempt bonds, contribute to retirement accounts, or own other assets that generate capital gains.

There are various ways of introducing tax avoidance into the basic labor supply model. Recent interesting theoretical studies include Mayshar (1991), Feldstein (1999) and Slemrod (1998). Feldstein considers the case when tax avoidance takes the form of consumption of goods that are tax-favored either through deductions or exclusions, and he adds these categories to a utility function that also includes leisure and non-favored consumption. By using the TAXSIM model he estimates deadweight loss of 10 times more than Harberger's classic 1964 estimate. He claims that the relatively low estimated elasticity of labor supply leads to this conclusion. Mayshar and Slemrod stick to the basic, two-good labor supply model, but introduce a general tax avoidance technology, which is intended to reflect a richer but unspecified structural model. In Slemrod's(1998) model, for example, individuals can reduce their tax liabilities by involving tax avoidance activities at some cost. He studies the comparative statistics and compares the labor supply elasticity in standard models with that of avoidance models for some specified avoidance cost functions. Slemrod and Yitzhaki (1999) analyzes tax evasion, tax avoidance and tax administration issues in a very broad way. They do not provide a model for tax avoidance; instead they discuss the related literature in detail. Desai and Dharmapala (2008) investigate whether the composition of outbound capital flows from the U.S. reflects the desire to circumvent home and host country institutional and tax regimes. Their results suggest that a 10% decrease in a foreign country's corporate tax rate increases US investors' equity foreign portfolio investment holdings by approximately 10%. Therefore, they conclude that the distortion to portfolio choices induced by worldwide corporate taxes should be taken into account in welfare analysis of corporate taxation in a global setting.

I contribute to the relevant literature by considering tax arbitrage as a means to avoid tax and also by combining it with standard models. In other words, this work differs from Feldstein (1999) and Slemrod (1998) in the way that avoidance is incorporated into the model. I assume that individuals can reduce their tax liabilities by engaging in asset trading (i.e buying and selling tax-favored assets and normal assets). I believe that the portfolio approach has some appealing properties. It allows for the fact that not all tax-payers engage in tax avoidance. Because of constraints on short sales, avoidance will be concentrated among the rich. Also, it takes into account that many avoidance operations involve both a buyer and a seller. This demand and supply approach highlights the influence of relative asset yields in shaping the budget constraints of avoiders. Finally, based on partial equilibrium analysis, Feldstein (1995b) argues that tax avoidance increases the excess burden from income taxation to a considerable extent. But as I discuss below, the portfolio approach implies that the efficiency implications depend on general equilibrium considerations.

I show that failure to account for tax avoidance leads to biased predictions about the labor supply response and excess burden of income tax. In my model, through asset trading tax-payers can reduce their tax liabilities. This causes the effect of a tax change on labor supply to be modest. I find that the substitution effect will be smaller in my model because effective marginal tax change will be less then the statutory tax change. Also, taxation leads to sub-optimal asset allocation and this causes the excess burden of tax to be greater than what standard models predict. When I allow asset returns to be endogenous and assume that supply of the assets is fixed, the total excess burden in the economy will be the same with standard models. However, when the supply of assets increases with its price, the excess burden will be greater than what standard models estimate but smaller than my estimate for the perfectly elastic asset supply case.

The rest of the paper is organized as follows. In section 2, a simple tax avoidance model is presented with two riskless assets. In section 3, the return on tax exempt asset is assumed to be uncertain. Section 4 presents some general equilibrium aspects. Finally, section 5 concludes the paper.

1.2 A Simple Tax Arbitrage Model

Consider an individual with an hourly wage rate w, labor supply ℓ , and a time endowment of H hours. The utility function is , $U(c, H-\ell)$, quasi-concave, and twice continuously differentiable. The government imposes an income tax schedule $T(B)$ where B is the taxable income. The only thing that distinguishes my set-up from the standard, static labor supply model is that agents can buy and sell assets with different tax status. In other words, asset choice is endogenous in out model. More specifically, I assume that an individual has some wealth W, which is to be allocated between a tax-exempt (denoted X) and a fully taxable asset (denoted D).

So, $W = X + D$

I let r denote the interest rate on taxable claims, and d the interest rate on tax-exempt claims. I first start my analysis by assuming that both assets are risk-free. Later in section 2, I relax this assumption and impose uncertainty into the model. I may think of the tax-exempt asset as representing tax shelters like pensions savings, gold, land, etc., while the taxable asset represents ordinary bank lending, positive or negative. I assume that $r > d$ so that agents have a trade off between buying a taxable asset with higher return and buying a tax-exempt asset with low return. This will induce some individuals who face a high marginal tax rate to trade assets and reduce their tax liability(Tax Avoidance). There is a constraint on short sales of the tax-exempt asset, but people may go short in the taxable asset. This assumption guarantees that agents cannot take advantage of arbitrage without decreasing their tax liability. Selling tax-exempt asset and buying taxable asset will not reduce the tax liability. If I let taxpayers buy negative amount of X and positive amount of D, they will be increasing their consumption level without avoiding tax. Furthermore, without any constraint on X, in equilibrium all individuals will trade assets until their taxable incomes are equal.[1]

The taxable income and budget constraint of individuals can be written as follows;

$$B = r(W - X) + w\ell$$

$$c = dX + r(W - X) + w\ell - T(B)$$

So, the maximization problem becomes,

$$\underset{X,\ell}{Max} \quad U(c, H-\ell) \quad s.t \quad c = dX + r(W-X) + w\ell - T(B), \quad X \geq 0 \tag{1.1}$$

In the standard labor supply model, the individual optimizes with respect to (1.1) , while treating asset choice X as a constant. In my model the individual optimizes with respect to both ℓ and X. First order conditions from (1.1) are:

$$\frac{U_c}{U_L} = w[1 - T'(w\ell + r(W - X))] \tag{1.2}$$

$$d - r[1 - T'(w\ell + r(W - X))] \leq 0 \tag{1.3}$$

$$= 0 \quad if \ X > 0$$

First, consider the case of an interior solution(i.e $X > 0$). For these individuals, denoted by superscript "A" for "avoider", tax avoidance is driven to the point where the after-tax marginal return on the taxable asset, equals to return on tax exempt asset;

$$r[1 - T'(B)] = d \tag{1.4}$$

[1] I do not impose a non-negativity constraint on taxable asset. In general, especially relatively rich people can easily get bank loans. However, some individuals might be constrained with short selling the taxable assets in reality. For a general discussion of how capital market imperfections and government regulations affect the scope for tax arbitrage, see Stiglitz (1983).

Since everyone faces the same asset yields r and d in a competitive capital market, (1.4) implies that all individuals at an interior portfolio equilibrium will have the same marginal tax rate. For avoiders, tax avoidance will thus transform the nonlinear statutory tax schedule into an effective linear schedule with slope $1 - d/r$. For future reference it is important to note that this implies that

$$\frac{U_L^A}{U_c^A} = w\frac{d}{r} \tag{1.5}$$

Equation (1.5) implies that the effective tax wedge for avoiders is determined in asset markets. The tax system affects work incentives only to the extent that the tax function $T(.)$ affects the relative return on taxable and tax-exempt assets. Assuming that marginal tax rate is a monotone function of taxable income, all avoiders report the same taxable income:

$$B^A = T^{'-1}(1 - d/r) \tag{1.6}$$

Monotonicity of marginal tax function helps us to get taxable income in closed form. However it is not a critical assumption for the results I get.[2] When two individuals face different marginal tax rates, they can make a profit from trading assets. The one with the low income sells the tax-exempt asset and purchases the taxable asset, while the one with the high income does the opposite. This process continues until taxable incomes are equalized, and total tax payments minimized. However, because of the constraint on short sales the process of tax arbitrage might be cut short. People with relatively low taxable incomes, who face an incentive to go

[2] In the U.S. marginal tax function is not strictly increasing but rather it is piecewise linear. For such a tax system, eq.(1.4) implies that all avoiders will be in the same tax bracket even though they might have different taxable incomes. Thats why it will not effect our results.

short in the tax-exempt asset, will find that the non-negativity constraint prevents them from doing so. For this group of people all wealth will be invested in the taxable asset, and their labor supply will be determined in exactly the same way as is predicted by the standard labor supply model. Non-avoiders decide on work hours while treating their asset portfolio as exogenous, and accounting for the fact that they – unlike avoiders – face a tax system where the marginal tax rate is an increasing function of their labor income.

In sum, for tax avoiders, I have the response functions as below;

$$\begin{aligned} \ell^A &= \ell^A(w, W) \\ X^A &= X^A(w, W) \end{aligned} \tag{1.7}$$

To derive the labor supply function of non-avoiders, henceforth denoted by superscript "NA", I set $X = 0$ in (1.2).

$$\begin{aligned} \ell^{NA} &= \ell^{NA}(w, W) \\ X^{NA} &= 0 \end{aligned} \tag{1.8}$$

For a given utility function and tax system, wage rate(w) and initial wealth(W) determines whether individuals are avoiders or not. Using equation (1.3), define $\phi(w, W)$ such that:

$$\phi(w, W) = d - r[1 - T'(w\ell^{NA} + rW)]$$

Everybody with $\phi(w, W) > 0$ avoids and behaves according to (1.7), while everybody with $\phi(w, W) < 0$ does not avoid and behaves according to (1.8). It is easy to check $\phi(w, W)$ is increasing in w and W for fixed value of ℓ^{NA}. So, all else equal, higher income taxpayers are more likely to avoid tax. Also note that, taxable income of tax avoiders is determined by the curvature of the tax function and by the relative return on tax-exempt and taxable assets. Parameters from tax avoiders' utility functions play no role. This follows directly from equation (1.6). As a corollary, one can show that the choice of actually becoming an avoider does depend on the utility function. This follows from the derivation of $\phi(w, W$

My main interest is the labor supply and excess burden implications of tax arbitrage model compared to standard models. Since I start with relatively unrealistic model (no uncertainty in asset returns), for now, I give a brief overview of labor supply and excess burden implications of my simple model. For any arbitrary tax reform, the labor supply of a tax avoider is only affected by an income effect. This result holds for any individual who is at an interior portfolio equilibrium both before and after the tax reform. This conclusion follows directly from the first order condition in equation (1.5). A tax reform generates a substitution effect only if it affects the wedge imposed between the marginal rate of substitution on the LHS and the marginal rate of transformation on the RHS. Because this wedge is determined in asset markets, and equal to $1 - d/r$, a tax reform can have no direct impact on the wedge.

It is straightforward to compute the welfare loss associated with tax system $T(.)$. In an equilibrium without taxation, what lump-sum deduction(EV) would be equivalent to the introduction of tax ?[3] For endogenous asset choice model, define $V^T(w, W)$,as indirect utility obtained in taxation equilibrium and $V^{NT}(w, W)$, as indirect utility obtained in no-tax equilibrium. Then, EV of taxation is:

$$V^{NT}(w, W) = \underset{\ell}{Max} \qquad U(c, H - \ell) \qquad s.t \qquad c = rW + w\ell - EV \tag{1.9}$$

such that $V^{NT}(w, W) = V^T(w, W)$.The budget constraint recognizes that $X = 0$ for everybody in the absence of taxation. Since $r > d$, and there is no tax, no one will invest in the low-yielding asset[4].

Consider next, how the welfare cost is computed if endogeneity of asset choice is not recognized. Suppose that there is a complete information about the utility function, and that all variables including consumption, leisure, and asset holdings. To estimate the welfare cost of taxation in the standard labor supply model (i.e asset choice is exogenous), define $V'^{NT}(w, W)$, as indirect utility obtained in no-tax equilibrium. Then, $EV'$of taxation is:

$$V'^{NT}(w, W) = \underset{\ell}{Max} \qquad U(c, H - \ell) \qquad s.t \qquad c = d\bar{X} + r(W - \bar{X}) + w\ell - EV' \tag{1.10}$$

[3]To calculate the actual welfare loss we need to subtract tax revenue from equivalent variation. However, ignoring tax revenue doesn't effect my results.

[4]When tax rate is zero, there should not be any supply for the tax-exempt asset since there is no demand. The analysis would be the same when tax rate is very small but not zero. My goal is to show that when tax rates decrease, individuals will re-optimize their asset portfolio buy buying more taxable asset. Missing this point will result in underestimating the excess burden of the tax.

such that $V'^{NT}(w,W) = V^T(w,W)$. Where $\bar{X}$ is the optimal tax exempt asset holding in taxation equilibrium. Since the asset choice is treated as exogenous in the optimization problem, the asset income that appear in the budget constraint, $(d\bar{X} + r(W - \bar{X}))$, is the one that is observed in the equilibrium with taxation. So, comparing the two models in terms of efficiency cost of income tax (i.e. equivalent variations), I can state that: Calculations of the welfare cost of income taxation that treat asset choice as exogenous imply that the perceived welfare cost, EV', will be less than the true welfare cost, EV, by an amount given by $EV = EV' + (r - d)\bar{X}$.[5] I will use the same method of calculating the excess burden in the next section.

1.3 Uncertainty in Asset Returns

The model that I develop above yields some restrictive results with the assumption of two riskless assets. One of the unrealistic results in Section 1 is that all individuals who involve in tax arbitrage end up having the same effective marginal tax rate and the same taxable income. In addition to this, any tax rate change results in an income effect and no substitution effect. In this section I relax the assumption that assets are riskless. Specifically, I assume that there are two states of the world. At the end of the period, assets yield a "high" return (denoted by "h") in one state of the world and a "low" return (denoted by "l") in the other. The timing in economy is as follows: At the beginning of the period individuals have perfect information regarding their wage rates, initial endowments, and tax

[5]The proof follows directly from equalizing the budget constraints in optimization problems 1.9 and 1.10. By definition, $V'^{NT}(w,W)$ should be equal to $V^{NT}(w,W)$. If budget constraints in 1.9 and 1.10 are equalized indirect utilities in no tax equilibrium will be equal.

rates. They decide how much asset to buy and how much labor to supply at the beginning of the period. At the end of the period income from asset holdings are realized. With the probability of p, the"high" state is realized. Assets returns in the "high" state are d^h for the tax exempt asset and r^h for the taxable asset. With the probability of $(1-p)$ the "low" state is realized. Asset returns in the "low" state are d^l for the tax exempt asset and r^l for the taxable asset. With these assumptions about asset returns, individuals will not buy assets for diversification purposes since high state and low state are not asset specific.[6] In the current setting, tax exempt and taxable assets are no longer perfect substitutes.[7] In other words, individuals do not trade assets only by considering their relative return, they also take the risk they bear into account while making their portfolio. I also assume that $d^h < r^h$ and $d^l < r^l$. That is, the return on taxable assets is greater in both states of the world. Again, with this assumption agents have a trade off between buying a taxable asset with a higher return and buying a tax-exempt asset with low return no matter which state occurs.

Contingent taxable income(B) and consumption(c) of individuals can be written as follows:

$$B^h = w\ell + (W - X)r^h \qquad\qquad B^l = w\ell + (W - X)r^l$$

[6]Making more general assumptions for the asset returns and allowing individuals to buy asset for diversification purposes will not effect our main findings as long as the expected return on taxable asset is greated than expected return on tax-exempt asset. My simplifying assumption make the calculations easier. For more information about portfolio distortion of corporate tax with more general assumption about diversification see Desai and Dharmapala (2008).

[7]In an exceptional case, where relative returns of taxable and tax-exempt assets in high and low state are equal, two assets will still be perfect substitutes to each other.

$$c^h = d^h X + (W - X) r^h + w\ell - T(B^h) \qquad c^l = d^l X + (W - X) r^l + w\ell - T(B^l)$$

Individuals maximize their expected utility.

$$\underset{X,\ell}{Max} \quad pU(c^h, H-\ell) + (1-p)U(c^l, H-\ell) \quad s.t \quad c^h = d^h X + (W-X)r^h + w\ell - T(B^h) \tag{1.11}$$

$$c^l = d^l X + (W-X)r^l + w\ell - T(B^l)$$

$$X \geq 0$$

First order conditions(FOC.) for X and ℓ respectively are :

$$pU_c^h[d^h - r^h(1 - T'(B^h))] + (1-p)U_c^l[d^l - r^l(1 - T'(B^l))] \leq 0 \tag{1.12}$$

$$= 0 \quad if\ X > 0$$

$$p[wU_c^h(1 - T'(B^h)) - U_L^h] + (1-p)[wU_c^l(1 - T'(B^l)) - U_L^l] = 0 \tag{1.13}$$

U_c^h and U_c^l are first derivatives of the utility function with respect to c in the "high return" state and the "low return" state respectively. Likewise, U_L^h and U_L^l are first derivatives of utility function with respect to leisure(L) in the "high return" state and "low return" state, respectively. From equation (1.12) I can get the condition for becoming an avoider. I rewrite the first FOC. for $X = 0$.

$$pU_c^h d^h + (1-p)U_c^l d^l < pU_c^h r^h(1 - T'(w\ell + Wr^h)) + (1-p)U_c^l r^l(1 - T'(w\ell + Wr^l)) \tag{1.14}$$

The left-hand side of equation (1.14) is the expected marginal utility from buying one unit asset X, while the right-hand side is the expected marginal utility from buying a taxable asset (D). If an individual spends all his initial wealth(W)

on D and the expected marginal utility of D is still greater than that of X, then the individual does not buy any X in equilibrium. In other words, he does not avoid any tax through asset trading. When carefully examined, it can be seen that when initial wealth(W) increases, everything else being equal, equation (1.14) is less likely to be satisfied.[8] Hence, as people become richer they are more likely to be avoiders. This result appears consistent with the old saying among tax professionals that "the poor evade and the rich avoid," meaning that the rich tend to reduce their taxes through legal "avoidance" measures such as tax arbitrage, while those with lower incomes attempt more outright evasion. Given parameter values p, r^h, r^l, d^h, d^l, utility and tax functions define a function $\phi(w, W)$ such that

$$\phi(w, W) = [pU_c^h d^h + (1-p)U_c^l d^l] - [pU_c^h r^h(1-T'(w\ell + Wr^h)) + (1-p)U_c^l r^l(1-T'(w\ell + Wr^l))] \tag{1.15}$$

Individuals with $\phi(w, W) > 0$ will become avoiders while individuals with $\phi(w, W) \leq 0$ will not avoid any tax. For avoiders equation (1.12) holds with equality. That is, for taxpayers who buy a positive amount of X, in equilibrium expected marginal utility from buying 1 unit of X and 1 unit of D are equal. With uncertainty in asset returns, taxable income is now contingent upon different states of the world. Furthermore, taxable income (B^l, B^h) depends on preferences as well as the tax function and other parameters. One of the restrictive results in section1 is that every

[8] U_c^h and U_c^l are common in both side of the equation (1.14). On the right hand side $(1 - T'(.))$ term is extra. As W increase, it is easy to check marginal tax, $T'(.)$, to increase and $(1 - T'(.))$ term to decrease. Thus right hand side will increase more slowly or fall more rapidly compared to left hand side of the equation.

avoider has the same taxable income. Imposing uncertainty into the model leads to a more generalized result. Depending on individuals' preferences over risk, initial endowment and wage rate, the taxable income of avoiders will be different. Without uncertainty the two assets are perfect substitutes to each other, so individuals fully take advantage of tax arbitrage opportunities. With uncertainty, tax-exempt and taxable assets are no longer perfect substitutes.

Over the years, one of the main applications of labor supply analysis has been predicting how tax reform affects hours of labor supply, tax revenue, and excess burden. In the context of the major tax reforms that were implemented in the past, a number of studies have assessed the direction and magnitude of these effects.[9] Consider a tax reform that increases the progressivity of the tax function $T(.)$. What are the implications for the labor supply of avoiders?

The labor supply response to a change in tax system will have different implications with contingent asset returns. In section 1, I find that tax changes do not effect marginal tax, and thus tax changes have only an income effect on labor supply. In this section, I see in equation (1.12) that marginal tax, $T'(B^{h,l})$, depends on preferences and the tax function itself, $T(.)$. So, when tax function changes, the marginal tax that people face will change as well. Labor supply will not only be affected by the income effect but also by the substitution effect. This is in line with what standard labor supply models (with exogenous asset choice) suggest. However, the magnitude of the labor supply response to tax change in my model will

[9] See for example, Ziliak and Kniesner(1999) and Auerbach and Slemrod (1997) for US tax reform and Agell, Englund, and Sodersten (1998) for Swedish tax reform.

be different than what standard models predict. To find the labor supply response in both models, define $m^h = T'(B^h)$ and $m^l = T'(B^l)$ as current marginal tax rates in both states. Likewise, define $Z^h = d^h X + (W - X) r^h$ and $Z^l = d^l X + (W - X) r^l$ as non-labor income in both states. With non-labor income and current marginal taxes I can write the labor supply function as $L(w, W, m^h, m^l, Z^h, Z^l)$. Now, I totally differentiate labor supply function, marginal tax, and non-labor income to get,

$$dL = L_w dw + L_W dW + L_{m^h} dm^h + L_{m^l} dm^l + L_{Z^h} dZ^h + L_{Z^l} dZ^l \tag{1.16}$$

$$dm^h = T''(B^h)[dwL + dLw - dXr^h], \qquad dm^l = T''(B^l)[dwL + dLw - dXr^l] \tag{1.17}$$

$$dZ^h = dX(d^h - r^h), \qquad dZ^l = dX(d^l - r^l) \tag{1.18}$$

Assume that initial wealth and wage rate is fixed or it does not change with tax. Then $dw = dW = 0$. In standard models asset choice is exogenous and does not respond to tax changes. This means $dX = 0$. However, as a result of increased tax progressivity, my model suggests that individuals will buy more X to avoid some of the tax liability. With higher taxes, the marginal return on X will be greater and thus individuals will demand more of it. Hence, the change in X will be positive, $dX > 0$. So, the marginal tax rate change $dm^{h,l}$ will be smaller in my model. This is easy to see from equation (1.17).[10] Then I have $dm^h < dm^h_{std}$, $dm^l < dm^l_{std}$. Here, dm^h_{std} and dm^l_{std} are marginal tax rate changes in standard models while dm^h, dm^l are marginal tax rate changes in my model. Also, note that $dZ^l = dZ^h = 0$ in standard models since $dX = 0$, while $dZ^l, dZ^h < 0$ in my models.(see eq. 1.18 and

[10]Our model allows individuals to be able to reduce the statutory marginal tax unlike standard models. So it is intuitive to have a smaller effective marginal tax change in our model.

note that $r^h > d^h$ and $r^l > d^l$) Now let us compare the labor supply response in both models. Let dL_{std} be the labor supply response in standard models and dL be the labor supply response in my model. Then re-writing eq (1.16) for my model and standard models, I get:

$$dL_{std} = L_{m^h} dm^h_{std} + L_{m^l} dm^l_{std} \tag{1.19}$$

$$dL = L_{m^h} dm^h + L_{m^l} dm^l + L_{Z^h} dZ^h + L_{Z^l} dZ^l \tag{1.20}$$

Subtracting one from the other yields the following;

$$dL_{std} - dL = L_{m^h}(m^h_{std} - dm^h) + L_{m^l}(m^l_{std} - dm^l) - dX[L_{Z^h}(d^h - r^h) + L_{Z^l}(d^l - r^l)] \tag{1.21}$$

Suppose first, $L_{m^h}, L_{m^l} < 0$. That means increasing the marginal tax will lead to a decrease in labor supply for standard models, $dL_{std} < 0$. In other words, labor supply function is upward sloping. Also, note that $L_{Z^l}, L_{Zh} < 0$ since I assume that leisure is normal good. Then, the first two terms and the last term in the right-hand side of eq.(1.21) will be negative. This implies $dL > dL_{std}$. In other words, my model suggests that the labor supply response of a tax increase will be less negative than standard models, or it may be positive or even zero. There are two reasons for getting this result. One reason is that tax increase creates a smaller substitution effect in my model. This is trivial since marginal tax rate change will be smaller in my model as I showed above. Another reason for having a different labor supply response is that non-labor income is effected by tax changes in my model. When the tax rates increase, individuals will substitute away from taxable assets to tax exempt assets. This will cause non-labor income to decrease as I showed above in eq.(1.18). So, there is a non-labor income effect which will cause labor supply to increase. Therefore, an increase in the progressivity of the tax system may cause labor supply response to be positive, negative or zero depending on the magnitude of the different effects.

Now suppose, $L_{m^h}, L_{m^l} > 0$. That means that increasing the marginal tax will lead to an increase in labor supply for standard models, $dL_{std} > 0$. Eq. (1.20) implies that the labor supply response in my model will be positive too, $dL > 0$. The first two terms in the right-hand side of eq. (1.21) will now be positive and the third term is negative. So, it is ambiguous whether dL or dL_{std} is bigger.

Much of the interest in the standard labor supply model rests on the view that a correctly estimated (compensated) labor supply elasticity is a vital input when calculating the welfare cost of taxation. However, as first argued by Feldstein (1995b), when people optimize along several margins at the same time, the elasticity of the labor supply becomes a potentially misleading indicator of the welfare cost of taxation. In estimating excess burden of income tax with avoidance opportunities, the partial equilibrium model I present in this section is a special case in Feldstein (1995b). However, specifically modeling tax avoidance through tax arbitrage help us understand a real life avoidance practice better. Moreover, when I allow asset returns to be affected by tax policy in the next section, income tax may not have extra burden with avoidance.

In section 1, I found that excess burden of taxation is greater in my tax arbitrage model compared to standard models because asset choice behavior is also distorted in my tax arbitrage model. With uncertainty in the asset returns, I have similar results. To find the excess burden of taxation for the tax arbitrage model (where asset choice is endogenous), define $V^T(w, W)$, as the indirect utility achieved in taxation equilibrium. Let EV^h and EV^l denote the state dependent lump-sum deductions from consumption in no-tax equilibrium.I find EV^h and EV^l from the following maximization problem. Let $V^{NT}(w, W)$ be the indirect utility function obtained from,

$$\underset{\ell}{Max}\ pU(c^h, H-\ell) + (1-p)U(c^l, H-\ell) \quad s.t \ \ c^h = r^h W + w\ell \ - EV^h \qquad (1.22)$$
$$c^l = r^l W + w\ell - EV^l$$

such that $V^T(w, W) = V^{NT}(w, W)$. Since the return of the taxable asset is greater in both states, without taxation, individuals will not buy any tax exempt assets(X) and will buy taxable asset(D) with all of their endowments. It would be more practical to have a single measure of excess burden rather than having a state dependent excess burden. That's why I define EV as the certainty equivalent of subtracting EV^h in "high" state and EV^l in "low" state from consumption. EV is calculated by using the following equation;

$$pU(r^h W + w\ell - EV^h, H-\ell^*) + (1-p)U(r^l W + w\ell - EV^l \ , H-\ell^*) \qquad (1.23)$$
$$= pU(r^h W + w\ell - EV, H-\ell^*) + (1-p)U(r^l W + w\ell - EV \ , H-\ell^*)$$

Where ℓ^* is the labor supply in equilibrium.

Now, let us see what would be the excess burden for a standard model (where asset choice is exogenous).I assume there is perfect information about the asset choice in taxation equilibrium. Again, let EV'^h and EV'^l be the lump-sum deduction from consumption in "high" and "low" states respectively. Following maximization problem yields EV'^h and EV'^l for a standard labor supply model. Let $V'^{NT}(w, W)$ be the indirect utility function obtained from,

$$\underset{\ell}{Max} pU(c^h, H-\ell) + (1-p)U(c^l, H-\ell) \qquad \text{s.t} \qquad c^h = d^h\bar{X} + (W-\bar{X})r^h + w\ell - EV'^h, \tag{1.24}$$
$$c^l = d^l\bar{X} + (W-\bar{X})r^l + w\ell - EV'^l$$

such that $V^T(w, W) = V'^{NT}(w, W)$. This implies that the indirect utility obtained in problems (1.22) and (1.24) must be the same. Note that $\bar{X}$ shows the amount of tax exempt asset held in taxation equilibrium. Individuals do not change their asset portfolio in standard models when there is no tax because asset income is assumed to be exogenous. Again, let EV' be the certainty equivalent of deducting EV'^h in "high" state and EV'^l in "low" state from consumption. Similarly, I can find EV' from the following equation.

$$pU(d^h\bar{X} + (W-\bar{X})r^h + w\ell - EV'^h, H-\ell'^*) + (1-p)U(d^l\bar{X} + (W-\bar{X})r^l + w\ell - EV'^l, H-\ell'^*) \tag{1.25}$$
$$= pU(d^h\bar{X} + (W-\bar{X})r^h + w\ell - EV', H-\ell'^*) + (1-p)U(d^l\bar{X} + (W-\bar{X})r^l + w\ell - EV', H-\ell'^*)$$

Where ℓ'^* is the labor supply in equilibrium for standard models.

Next, I find a relationship between state dependent deductions in two models. Carefully examining the maximization problems (1.22) and (1.24) , I can state that with the following characterization the two maximization problems become the same and thus yield the same utility level.

$$EV^h = EV'^h + (r^h - d^h)\bar{X}, \quad EV^l = EV'^l + (r^l - d^l)\bar{X} \ \text{ and } \ \ell^* = \ell'^*$$

With these equations, the left-hand side of equations (1.23) and (1.25) are equal. Hence, the right-hand side of these equations will be equal to each other as well;

$$pU[r^h W + w\ell^* - EV, H - \ell^*] + (1-p)U[r^l W + w\ell^* - EV \ , H - \ell^*] \tag{1.26}$$
$$= pU[d^h\bar{X} + (W - \bar{X})r^h + w\ell'^* - EV', H - \ell'^*] + (1-p)U[d^l\bar{X} + (W - \bar{X})r^l + w\ell'^* - EV', H - \ell'^*]$$

my goal is to compare EV and EV'. The second term of the utility function (leisure) is equal in both sides since $\ell^* = \ell'^*$. So, I concentrate on the first terms (consumption). Since $r^h > d^h$ and $r^l > d^l$, I have the following;

$$r^h W + w\ell^* > d^h\bar{X} + (W - \bar{X})r^h + w\ell'^*$$

$$r^l W + w\ell^* > d^l\bar{X} + (W - \bar{X})r^l + w\ell'^*$$

Now, (1.26) holds if and only if $EV > EV'$. Thus, I show that excess burden in my model is greater than that of standard models. The difference in excess burdens in different models is caused by the asset portfolio being exogenous in standard models. The extra burden in my model reflects the expected amount of asset income that would have been gained had the individuals been allowed to choose their asset portfolio in standard models with no tax. To the extent that taxation leads to an equilibrium with an inefficient asset allocation, an analysis that ignores this fact underestimates the welfare cost of taxation. This result is similar to Feldstein(1999) which finds the excess burden of taxation to be ten times greater than "Harberger Triangle" in the existence of avoidance. In his study, tax avoidance is through changes in the form of compensation (e.g., employer paid health insurance) and through changes in the patterns of consumption (e.g., owner occupied housing).

1.4 General Equilibrium Considerations

In previous sections I assumed that both taxable and tax exempt assets were in infinite supply. That is why the tax system changes did not affect the asset returns. In an open economy, it might appear reasonable to assume that asset yields are independent of domestic tax policy. But in an economy where the supplies of taxable and tax-exempt assets are less than perfectly elastic, it seems reasonable to proceed under the assumption that domestic tax policy affects the relative asset yield. For simplicity, I do not consider the uncertainty in asset returns here. I assume that there is no uncertainty in the asset returns as in section1. It is straightforward to introduce endogenous asset yields in my model. A basic observation is that although there are two assets in the model, there is only one independent equilibrium condition. Thus, I can only solve for relative asset returns .For now, assume that the tax-exempt asset(X) is in fixed supply, denoted by $\bar{S}$ [11](Later I relax this assumption). This would be the case if X is, for example, land. Then, I integrate the asset demand function in (1.7) over all tax avoiders to obtain

[11]Since the total initial wealth in our model is fixed, assuming only tax exempt asset is fixed, implicitly means assuming fixed supply for taxable asset.

market demand for the tax-exempt asset, and I solve for the value of d/r that makes demand equal to supply,

$$\int_{\phi(w,W)>0} X^A(w,W,d/r)dF(w,W) = \bar{S} \tag{1.27}$$

where $F(w,W)$ is the joint cumulative distribution function of wages and initial wealth. Using (1.27), I can examine how tax reform affects the relative asset yield. With this information I can proceed to examine the implications for labor supply, tax revenue, and the welfare cost of taxation.

First, I compare my finding here with what I find in section 1 because in this section I assume asset returns are riskless just like in section 1. When the tax system affects the relative asset yield, tax reform also creates substitution effects for those who engage in tax avoidance. In the standard model the labor supply of high-wage individuals tends to decrease because of a negative substitution effect. In my model, with an endogenous asset yield the labor supply of tax avoiders is affected by a negative substitution effect because increased statutory tax progressivity leads to a decrease in d/r . When statutory tax progressivity increases, there is an increased demand for the tax exempt asset. But as the tax exempt asset is in fixed supply, this excess demand must be choked down by a relative return adjustment that makes it less favorable to own the tax-exempt asset. In the process the effective marginal tax rate that confronts tax avoiders will increase.

Another important deviation from my previous analysis concerns the computation of the welfare cost of taxation. When the tax-exempt asset is in fixed supply, it is no longer the case that tax avoidance imposes an excess burden which is additional to the standard labor supply distortion. Although people still engage in asset trade to avoid taxation, no real resource costs are used up in the process. At the individual level, some people will hold more of the asset, and some will hold less, than they would have in the absence of taxation. These effects will, however, average out in the aggregate.[12]

Clearly, the assumption that assets are in fixed supply is not a realistic one. Let us assume that the supply of the tax-exempt asset is neither perfectly inelastic nor perfectly elastic. Specifically, let us say the supply function of the tax-exempt asset is $S(d/r)$. Again, to find the asset return ratio in equilibrium, I equalize the demand and supply.

$$\int_{\phi(w,W)>0} X^A(w,W,d/r)dF(w,W) = S(d/r) \tag{1.28}$$

Now let us try to see the effect of increased tax progressivity on labor supply and excess burden. First, there will be a substitution effect on labor supply. When the progressivity of the tax system increases, the demand for the tax-exempt asset will increase. In equilibrium, relative asset return, d/r, will decrease. Since supply is not fixed, the overall number of tax-exempt assets traded will go up. Marginal taxes for many individuals will go up but it will be less than the statutory progressivity.

[12]This result is in contrast with Feldstein(1999) which finds the excess burden of taxation to be ten times greater than "Harberger Triangle" in the existence of avoidance. The difference is caused by general equilibrium model versus partial equilibrium model in Feldstein(1999). In general equilibrium model relative price of leisure and deductables are dependent upon income tax.

Second, the welfare cost of taxation will be greater than that of standard labor supply models. There will be more tax exempt assets held by individuals after the increase in tax progressivity. There might be some individuals with relatively less initial wealth who sell the tax exempt asset. But there will be more people who will buy more tax-exempt assets after the increase in progressivity. Thus, tax arbitrage will create an extra burden in the economy as a whole, but it will be less than the perfectly elastic asset supply case.(i.e as in section1)

1.5 Conclusion

What keeps people working, given the very high marginal tax rates that can be observed for some countries? The traditional answer has been that labor supply is rather inelastic. my proposed answer is different. With the tax avoidance technologies that became increasingly available in the last decades, those who care about incentives need not pay those high tax rates.

This paper fills a gap in the public finance literature by exploring the labor supply distortion and its magnitude when individuals avoid income tax. I formalize the idea that high marginal tax rates could be circumvented by people with access to modern financial markets, and I state some implications for the empirical analysis of labor supply. I show that the standard approach of analyzing labor supply, which treats asset choice as exogenous, may give a very biased impression of how progressive income taxation affects hours supply, efficiency, income distribution and tax revenue. The standard approach overestimates the negative-hours response of people with high wages (i.e avoiders) to an increase in tax progressivity. It also overstates the extent of income redistribution that takes place and the revenue gains for the government. By neglecting the role of portfolio adjustments, the standard approach also underestimates (subject to the qualifications discussed in section 5) the overall efficiency losses imposed by high marginal tax rates.

Auerbach and Slemrod (1997) find in their study of the U.S. Tax Reform Act of 1986 that the most responsive decisions were financial and accounting activities. They claim that these activities primarily serve the purpose of affecting reported income, while activities like labor supply, savings, and investment seemed to respond very little to tax reform. In their study of the Swedish tax reform of 1990-91, Agell, Englund, and Södersten (1998) find that labor supply appeared unresponsive despite marginal rate cuts between 24 and 27 percentage points for large groups of full-time employees. The model I present in this paper helps us understand these empirical findings better.

There might also be real resource costs associated with tax avoidance (e.g. money and time spent for avoidance activities). Furthermore, avoidance responses are not the only behavioral responses to increasing tax rates. Higher marginal taxes may also induce tax-payers to evade some of their tax liability. These costs should also be considered when correctly estimating the dead-weight loss of an income tax. My paper does not take these costs into account. Nevertheless, from my work, one can get an idea about the direction of the bias in traditional labor supply studies which treats asset income exogenously.

I believe that the mechanisms analyzed in the present paper are quite relevant in countries with high marginal tax rates, non-uniform capital taxation, and developed financial markets. In countries with less developed financial markets, lower marginal tax rates, and/or uniform capital taxation, there is less scope for avoidance. Also, my model is a single-period one, and it does not account for the fact that there is an intertemporal dimension to many tax arbitrage strategies (e.g. the postponed taxation associated with pension plans). Developing models that explore the implications of such alternative mechanisms certainly seem like a worthwhile exercise.

Chapter 2

The Marginal Cost of Public Funds in the Presence of Tax Evasion

2.1 Introduction

To fund unexpected public expenses or new public projects, a government usually imposes additional distortionary taxes such as labor or capital income taxes even though the higher tax liabilities could stimulate taxpayers to cheat the government. The Internal Revenue Service (IRS) in the United States reports that the estimate of income tax liabilities not collected for 2001 is about 17%, which translates into $345 billion.[1] For cases in most other countries, the estimates are even higher. In 2003, the income tax evasion was around 25% in France and 30% in the United Kingdom.[2] Taxpayers can reduce the burden of complying with tax liability by underreporting income, but they have the risk of being caught in evasion which generates another welfare cost. Therefore, when a government levies distortionary taxes for public funds, the tax evasion itself matters. Taxpayers may or may not have excess burden through the behavior of tax evasion. However, the taxpayers are assumed to pay their tax liabilities fully in most economic analyses for evaluating public projects, even though the whole revenue from the tax liabilities is not collected in practice.

[1] See Internal Revenue Service, U.S. Department of the Treasury (2006).
[2] See [18] for more detailed discussion.

For the purpose of evaluating the public expenditures, a related literature employs a widely known concept of marginal cost of public funds (MCF), which measures the direct tax burden plus the marginal welfare cost from raising additional tax revenues.[3] However, including the prominent works of Browning (1976, 1987), almost all subsequent research does not reflect the aspects of tax evasion in MCF calculation. Even though [34] analytically measures the MCF for nonlinear income tax in a general equilibrium model, he does not incorporate the tax evasion as a behavioral response to a tax change. As noted by [48], the existence of tax evasion produces a risk-bearing cost in another form of excess burden. Nevertheless, he does not measure the MCF in the presence of tax evasion.[4]

Our purpose in this paper is to measure MCFs for alternative revenue-raising policies analytically when the tax evasion matters. In order to do so, we develop an analytical general equilibrium model in which taxpayers have an expected utility function, and a government imposes nonlinear income tax, audit, and fine rates, to fund public goods and lump-sum transfers.[5] Since distortionary taxes are the main instruments for public funds, it is important to know welfare cost to the use of income tax in the presence of tax evasion. Using a cost-benefit framework as presented in [34], we derive a "modified" MCF for nonlinear income tax ($\mathrm{MCF_T}$) in the context of tax evasion and then identify as the key determinants the expected return and

[3]See [12] and [34] for the definition of MCF. This concept originates in the argument of [36].

[4]Slemrod and Yitzhaki (1996, 2002) mention possible ways to incorporate tax evasion into the calculation of marginal efficiency cost of funds (MECF) very broadly but do not present any analytical model, so they do not derive the MECF (or MCF) as a function of easily observable exogenous parameters.

[5]We extend a standard partial equilibrium model of tax evasion such as is presented in [3].

variance of \$1 evaded, which consist of only audit and fine rates, implying the "riskiness of tax evasion."[6] On the other hand, a government audits more taxpayers or puts higher penalties on tax evaders to increase compliance and raise public funds.[7] Hence, we derive MCF for audit (MCF_p) and MCF for fine (MCF_θ) once more to examine welfare cost of tax enforcement policies. The remainder of this work provides numerical examples of MCFs for policy recommendation for the U.S. economy.

The main contribution of this paper is to present exact MCFs that are applicable to practical use as analytic formulae. To measure MCF_T analytically, we endogenize the behavior of tax evasion in a model closer to the actual tax environment. This analysis is not limited to the labor-leisure choice problems as used in Browning (1976, 1987), [21], [34], and [7] but take actual taxpayer behaviors into account. Taxpayers mitigate the burden of tax compliance by evading tax while they bear a risk cost of being caught. The model of this paper considers not only tax distortion of labor supply but also risk-bearing cost of tax evasion, to derives MCF_T in a general version of those in a number of papers as listed above that do ignore tax evasion. Thus, the MCF_T becomes an exact measure for evaluating public expenditures. In addition, resting on the rich model environment in this paper, we obtain MCF_p and MCF_θ. The two analytic formulae together with MCF_T allow ones to compare the alternative revenue-raising policies on efficiency grounds.

[6]The MCF_T includes tax enforcement policies as newly important parameters that the previous works with no tax evasion do not identify.

[7][43] recognize that audit or penalty rates can be used to raise revenue when the tax evasion is present in a model and state that it is optimal to equalize marginal costs of raising revenue for the two alternatives at the margin.

To our knowledge, this analysis is the first attempt on such a policy comparison. Therefore, the set of $\mathrm{MCF_T}$, MCF_p, and MCF_θ provides a criterion for evaluating alternative revenue-raising policies for a given level of public funds. Consequently, this paper fills the gap between the literatures on MCF and on tax evasion.

It is shown analytically that $\mathrm{MCF_T}$ is greater with tax evasion than with no tax evasion. This is due to the riskiness of tax evasion that tax enforcement policies (audit and fine rate) introduce. If the tax evasion exists, an increase in income tax rate raises both tax distortion of labor supply and riskiness of tax evasion, stimulating less labor supply but more tax evasion. When the tax evasion does not matter, an increase in income tax rate raises only the tax distortion of labor supply, however. The $\mathrm{MCF_T}$ with no tax evasion is the same as in [34]. In this sense, this paper extends Mayshar's $\mathrm{MCF_T}$ exactly to the tax evasion case. By using the parameter values that [45] suggests for the U.S. economy and finding proper values of audit and fine rates from the model, we show that the numerical estimate of $\mathrm{MCF_T}$ with tax evasion is 1.155 while the estimate without tax evasion is 1.076.[8] When elasticities of labor supply are positive and marginal resource cost of enforcement is sufficiently low, MCF_p and MCF_θ are less than 1, whereas $\mathrm{MCF_T}$ is greater than 1. If net-wage-rate elasticity of labor supply is positive, an increase in income tax rate worsens the preexisting distortions of labor supply and tax evasion.[9] On the other hand, if audit- and fine-rate elasticities of labor supply are positive,

[8]The numerical calculation uses the audit rate of .38 and the fine rate of 2. Furthermore, it assumes that the collected revenue is used only for a tax-neutral government project.

[9]The positive elasticity of labor supply with respect to net wage rate implies that the labor-supply curve is upward sloping.

an increase in audit or fine rate alleviates the preexisting distortions.[10] Hence, tax reform and enforcement reform could be complements rather than substitutes in this case. However, the magnitude of MCFs varies according to elasticities of labor supply and marginal resource cost of enforcement in general.

This paper is organized as follows. In the next section, we present a general equilibrium model of tax evasion that can be used to measure MCFs and find the condition under which the tax evasion exists. Sections 3 introduces a marginal revision in nonlinear income tax to derive $\mathrm{MCF_T}$. In section 4, we consider a marginal change in audit and in fine to derive MCF_p and MCF_θ respectively. Using benchmark parameters that represent the U.S. economy, section 5 calculates the MCFs numerically, evaluates the alternative revenue-raising instruments, and gives policy implications. We note limitations on this analysis and offer future research in the concluding section.

2.2 Model

2.2.1 Taxpayer

Consider an economy in which there is a unit measure of identical taxpayers. Each individual taxpayer has a quasi-concave and twice differentiable utility function $U(C, V, G)$, where C is consumption of marketable goods, V is leisure, and G represents a publicly provided nonmarketable good. The taxpayers have three different kinds of income sources. They earn a wage at a rate w by supplying their

[10] Audit rate elasticity refers to the elasticity of labor supply with respect to audit rate whereas fine rate elasticity refers to the elasticity of labor supply with respect to fine rate.

labor L from one unit of time $(1 = L + V)$ and get an interest I by renting their stock of capital K_0 endowed. In addition to these incomes, each taxpayer receives an amount of government transfer C_0 in a lump sum fashion. However, the privately earned labor incomes above are subject to a nonlinear tax schedule T; thus, the government revenue is $R = T(wL, \phi_T)$, where ϕ_T is a vector of marginal tax rates m and an average tax rate t that the taxpayers face.[11] The taxpayers are prone to hide some of their tax liability, however, since the tax-collection agency cannot observe all the earned incomes in the economy and, thus, audits only a fraction of them. In order to prevent the taxpayers from evading their labor tax, the government employs an enforcement mechanism ϕ_E that is a pair of an auditing rate p on the population and a fine rate $\theta = 1 + \pi$ on the amount evaded, where $\pi > 0$ is the penalty rate. It is assumed that if it investigates a taxpayer's declared income, a tax-collection agency immediately discovers tax evasion. Each individual makes the decision of labor supply at the beginning of the period and, in turn, reports some portion of their labor income X to the tax-collection agency. These reports determine the after-tax income ex-ante. At the end of the period, the taxpayer's actual level of consumption becomes clear according to one of two possible states. That is, he finds his amount of consumption $C_1 = I + wL - T\left(X, \phi_T\right) + C_0$ when not caught evading tax as state 1, whereas $C_2 = I + wL - T(X, \phi_T) - \theta\left[R - T(X, \phi_T)\right] + C_0$ in the case of being caught evading tax as state 2.[12] Denoting the tax evaded $R - T(X, \phi_T)$ as

[11] As in [45] and [34], we assume that the government puts a tax only on the labor incomes, and therefore $T_I = 0$. This assumption allows us to compare our result to those of Stuart and Mayshar. But, it could be rather straightforward to extend to the case of nonlabor income taxation.

[12] This setup slightly differs from Allingham-Sandmo (A-S) model. Here, the penalty paid by the taxpayer is a function of the tax evaded, whereas in the A-S model the penalty rate is on the

E, the budget constraint at each of two states can be rewritten as

$$\begin{cases} C_1 = I + wL - R + E + C_0 & \text{if the taxpayer is not caught evading,} \\ C_2 = I + wL - R - \pi E + C_0 & \text{if the taxpayer is caught evading.} \end{cases} \tag{2.1}$$

Furthermore, when the tax collection agency audits each taxpayer at a probability of detection p, the taxpayer has an expected utility function:

$$\bar{U} = \bar{U}\left(C_1, C_2, V, G, p\right) = (1-p)U(C_1, V, G) + pU(C_2, V, G). \tag{2.2}$$

2.2.2 Tax evasion and labor supply

This subsection looks into the taxpayer's decisions on labor supply and tax evasion and derives a condition under which the tax evasion exists. This condition will have an important implication on the results in the next two sections. Regarding a market wage rate w, a nonlabor income I, and the government fiscal program Ω as exogenously given, the individual taxpayer chooses each of two possible consumption levels (C_1, C_2), a level of leisure V, and an amount of tax evasion E to maximize the expected utility in eq. (2.2) subject to two budget constraints in eq. (2.1).[13] Therefore, the corresponding Lagrangian is

$$\begin{aligned} \mathcal{L} &= (1-p)U(C_1, V, G) + pU(C_2, V, G) \qquad (2.3) \\ &+ \lambda_1\left[I + wL - T(wL, \phi_T) + E + C_0 - C_1\right] + \lambda_2\left[I + wL - T(wL, \phi_T) - \pi E + C_0 - C_2\right], \end{aligned}$$

income evaded or underreported income. See [47], [17], [43] for more detail.

[13]Before we move on to the maximization problem of the taxpayer, it is worth mentioning about the timing in the economy. First, each of the individuals faces the policy parameters (p, t, θ). Then the equilibrium labor supply, evasion and wage are determined simultaneously. Finally, government transfers and consumption level are realized. Note that policy parameters (p, t, θ) do not come from an optimization problem. In other words, government does not optimize with respect to these policies. If the government maximized total utility with respect to these policy parameters, marginal excess burden of these policies would have been the same at the optimum.

where λ_1 and λ_2 are the weighted marginal utility of income according to each of two states. Setting the partial derivatives of the above Lagrangian equal to zero finds the first order conditions:

$$\mathcal{L}_{C_1} = 0: \quad (1-p)U_C(C_1, V, G) = \lambda_1, \tag{2.4}$$

$$\mathcal{L}_{C_2} = 0: \quad pU_C(C_2, V, G) = \lambda_2, \tag{2.5}$$

$$\mathcal{L}_{E} = 0: \quad \lambda_1 - \pi\lambda_2 = 0, \tag{2.6}$$

$$\mathcal{L}_{V} = 0: \quad (1-p)U_V(C_1, V, G) + pU_V(C_2, V, G) = (\lambda_1 + \lambda_2)(1-m)w. \tag{2.7}$$

Evaluating the partial derivative $\mathcal{L}_E$ at $E = 0$ together with eqs. (2.1), (2.4), and (2.5), and then setting it greater than zero gives the condition for tax evasion to appear $(E > 0)$

$$\mu \equiv 1 - p\theta > 0, \tag{2.8}$$

where μ represents the expected payoff of one dollar evaded, $(1-p)\cdot 1 + p \cdot (-\pi)$. Note that the tax parameters ϕ_T in the nonlinear tax function do not affect whether the taxpayers evade or not. The existence of tax evasion depends only on the enforcement mechanism ϕ_E. If the expected return μ is less than or equal to zero, then the risk averse taxpayers must not evade any amount of their tax liability.[14] Just in the case of earning positive expected returns to one dollar evaded, the taxpayers evade a fraction of tax that depends on a degree of risk preference as well as a level of payoff expected. That is, the positive expected payoff in eq. (2.8) could

[14]If $\mu = 1 - p\theta \leq 0$, there exists a corner solution which implies no tax evasion, $E = 0$. Thus, the condition in (2.8) guarantees an interior solution, $E > 0$.

be interpreted as a gamble favorable to the taxpayers.[15] This condition will play a key role in the two next sections. Plugging eqs. (2.4) and (2.5) into eq. (2.6) and (2.7) yields two equations

$$\frac{U_C(C_1, V, G)}{U_C(C_2, V, G)} = \frac{\pi p}{1-p}, \tag{2.9}$$

$$\frac{(1-p)U_V(C_1, V, G) + pU_V(C_2, V, G)}{(1-p)U_C(C_1, V, G) + pU_C(C_2, V, G)} = (1-m)w, \tag{2.10}$$

respectively. Eq. (2.9) shows that the marginal rate of substitution between consumptions of state 1 (not caught) and state 2 (caught) should be equal to the ratio of ex-ante income loss relative to gain for one dollar evaded. An increase in either probability of detection, penalty rate or both decreases tax evasion as the marginal utility of consumption in state 1 becomes relatively higher than in state 2. In eq. (2.10), the mean marginal rate of substitution between leisure and consumption is equated with net wage rate. Hence, a higher marginal tax rate or a lower wage rate acts as a disincentive to labor supply since the mean marginal utility of leisure gets relatively lower than that of consumption.

2.2.3 Firm

By borrowing a fixed stock of capital and employing a level of labor from the individuals, an aggregated firm produces market product $Y = f(K_0, L)$, where the production technology f has positive and diminishing productivity. Given the product price of one (normalized for simplicity), a wage rate, and a capital rental rate, the firm maximizes its profit $\Pi = f(K_0, L) - I - wL$, which gives the wage

[15] A gamble is said to be fair (unfavorable) if it has a zero (negative) expected return. See [2] and [48] for more discussions

rate and nonlabor income as follows:

$$w = f_L(K_0, L), \tag{2.11}$$

$$I = Y - wL. \tag{2.12}$$

Then the firm's demand and the individuals' supply for labor together with the fixed level of capital determine an equilibrium wage rate and an equilibrium rental price of capital in the competitive factor markets.

2.2.4 Government

Since the size of population is measured as one, the probability of detection p implies the ratio of taxpayers caught evading tax relative to all the taxpayers. Therefore, the government revenue is

$$\begin{aligned} \bar{R} = \bar{R}(wL, E, \phi_T, \phi_E) &= (1-p)(R-E) + p(R+\pi E) - h(p,\theta) \\ &= R - (1-p\theta)E - h(p,\theta). \end{aligned} \tag{2.13}$$

In eq. (2.13), both of labor income and tax evaded affect the revenue $\bar{R}$. Note that if all the individuals report their incomes truthfully and pay their tax liabilities, the government collects the revenue equal to $R - h(p,\theta)$. To secure a particular level of revenue, the government can employ the nonlinear income taxes ($\phi_T = (m,t)$) or force the taxpayers to pay the taxes they owe ($\phi_E = (p,\theta)$). The resource cost $h(p,\theta)$ is increasing in audit and fine rates, i.e. $h_p \geq 0$ and $h_\theta \geq 0$. The government needs some portion of the collected revenue to cover the cost of detecting tax evasion and penalizing tax evaders for dishonesty. The rest is used to finance the supply of a nonmarket good $G = g(R_G)$ and the transfer of market goods $C_0 = e(R_C)$

in which the technology of government production g and the transfer efficiency e satisfy $g' > 0 > g''$ and $e' > 0 > e''$, and two tax revenues R_G and R_C (in terms of market goods) are spent for G and C_0 respectively. Consequently, the government budget constraint becomes $R_G + R_C = \bar{R}$, and the set $\Omega = \{G, C_0, \phi_T, \phi_E\}$ stands for the government fiscal program.

2.3 Tax reform

In two consecutive sections, we consider a balanced-budget marginal revision in the government fiscal program Ω, including either a nonlinear tax reform that alters ϕ_T or an enforcement reform that alters ϕ_E and a corresponding reform in spending that changes G and C_0. Following the cost-benefit framework as in [34], this section first investigates the effect of a marginal revision only in the nonlinear tax schedule on the welfare of individuals. The tax reform and corresponding reform in spending $\{G, C_0, \phi_T\} \subset \Omega$ are desirable if total change in the taxpayer's expected utility is positive or equal to zero:

$$d\bar{U} = \bar{U}_{C_1} dC_1 + \bar{U}_{C_2} dC_2 + \bar{U}_V dV + \bar{U}_G dG \geq 0. \tag{2.14}$$

Even though $\bar{U}$ depends on p as shown in eq. (2.2), there is no variation in $\bar{U}$ with respect to p since a government does not consider any marginal changes in enforcement policies. Differentiate the taxpayers' two state-dependent budget constraints in eq. (2.1), the interest in eq. (2.12) and the government revenue function in eq. (2.13) to get $dC_1 = dY - dR + dE + dC_0$, $dC_2 = dY - dR - \pi dE + dC_0$, and $d\bar{R} = dR - \mu dE$. Furthermore, we have $dV + dL = 0$ from one unit of time and $dY = wdL$ by differentiating the production function and then using the wage rate in eq. (2.11). Combining these equations together with the first-order conditions in eqs. (2.4) - (2.7) gives

$$\left[\bar{U}_G / \left(\lambda_1 + \lambda_2\right)\right] dG + dC_0 \geq d\bar{R} + \mu dE - mwdL, \tag{2.15}$$

where the right- and left-hand sides of which indicate the marginal cost of tax reform and the marginal benefit of corresponding reform in spending in terms of dollar value.[16] Suppose that the government uses a share β of its marginal revenue $d\bar{R}$ to transfer the market goods and the remaining to supply the nonmarket good, i.e. $dR_C = \beta d\bar{R}$ and $dR_G = (1-\beta)d\bar{R}$. Dividing the left- and right-hand sides of eq. (2.15) by $d\bar{R} > 0$, we define the marginal benefit and cost of funds as follows:

$$\text{MBF} \equiv (1-\beta)g'(R_G)\left[\bar{U}_G / \left(\lambda_1 + \lambda_2\right)\right] + \beta e'(R_C) \geq 1 + \left(\mu dE - mwdL\right)/d\bar{R} \equiv \text{MCF}_\text{T}. \tag{2.16}$$

The left- and right-hand sides of eq. (2.16) imply the welfare benefit and cost of the marginal tax dollar to the individuals in this economy. Note that $R = T\left(wL, \phi_T\right) = twL$. Differentiating eq. (2.13) yields the marginal government revenue:

$$d\bar{R} = (1-\gamma)twdL + wLdt - \mu dE. \tag{2.17}$$

In eq. (2.17), $\gamma = \left(dw/dL\right)\left(L/w\right) = -Lf_{LL}/f_L$ is the elasticity of wage rate with respect to labor supply. Substituting eq. (2.17) into the marginal cost of funds in

[16] From eqs. (2.4), (2.5) and (2.7), $d\bar{U} = \lambda_1 dC_1 + \lambda_2 dC_2 + \left(\lambda_1 + \lambda_2\right)(1-m)\,wdV + \bar{U}_G dG$. Plug $dC_1 = dY - dR + dE + dC_0$ and $dC_2 = dY - dR - \pi dE + dC_0$ into this equation to get $d\bar{U} = \left(\lambda_1 + \lambda_2\right)\left[dY - dR + dC_0 + (1-m)\,wdV\right] + \left(\lambda_1 - \pi\lambda_2\right) dE + \bar{U}_G dG$. Since $dY = wdL$, $dV = -dL$, $d\bar{R} = dR - \mu dE$, and from eq. (2.6), $\lambda_1 - \pi\lambda_2 = 0$, we have that $d\bar{U} = \left(\lambda_1 + \lambda_2\right)\left[dC_0 - d\bar{R} - \mu dE + mwdL\right] + \bar{U}_G dG$. Finally, set $d\bar{U} \geq 0$, divide this inequality by $\lambda_1 + \lambda_2$, and rearrange it to arrive at eq. (2.15).

eq. (2.16) leads to the following:

$$\mathrm{MCF_T} = 1 + \frac{\mu dE - mwdL}{(1-\gamma)\, twdL + wLdt - \mu dE}. \tag{2.18}$$

If the expected payoff of one dollar evaded becomes less than or equal to zero ($\mu \leq 0$), each taxpayer does not evade any fraction of his tax on labor income ($E = 0$). Under this case, the taxpayer changes only his labor supply in response to the marginal revision in tax policy. Consequently, the marginal cost of funds in eq. (2.18) exactly reduces to that of [34]. However, our analysis generalizes Mayshar's formula. We derive the marginal cost of funds, including even the circumstance where taxpayers evade their tax liabilities ($E > 0$) when the expected payoff is greater than zero ($\mu > 0$). Hence, the taxpayer changes his tax evaded as well as labor supply when a government revises a given tax rate.

We evaluate the changes in tax evasion and labor supply, i.e. dE and dL in eq. (2.18), to derive $\mathrm{MCF_T}$ in terms of exogenous parameters in this model. The evaluation of dE needs log-linearization and Taylor expansion. Taking log and differentiating eq. (2.9) totally give the following:

$$\left[\frac{U_{CC}(C_1,V,G)}{U_C(C_1,V,G)}dC_1 - \frac{U_{CC}(C_2,V,G)}{U_C(C_2,V,G)}dC_2\right] + \left[\frac{U_{CV}(C_1,V,G)}{U_C(C_1,V,G)} - \frac{U_{CV}(C_2,V,G)}{U_C(C_2,V,G)}\right]dV$$
$$+ \left[\frac{U_{CG}(C_1,V,G)}{U_C(C_1,V,G)} - \frac{U_{CG}(C_2,V,G)}{U_C(C_2,V,G)}\right]dG = 0.$$

In the left-side of the above equation, the second and third terms vanish out since $\frac{U_{CV}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CV}(C_2,V,G)}{U_C(C_2,V,G)}$ and $\frac{U_{CG}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CG}(C_2,V,G)}{U_C(C_2,V,G)}$. The equation then reduces to

$$r\,(C_1)\,dC_1 = r\,(C_2)\,dC_2, \tag{2.19}$$

where $r(\cdot) \equiv -\frac{U_{CC}(\cdot,V,G)}{U_C(\cdot,V,G)}$ denotes the absolute risk aversion or curvature of utility function.[17] Two state-dependent marginal utility functions $U_C(C_1, V, G)$ and $U_C(C_2, V, G)$ can be approximated by the first-order Taylor expansion as follows:

$$U_C(C_1, V, G) = U_C(C_2, V, G) + U_{CC}(C_2, V, G)(C_1 - C_2),$$
$$U_C(C_2, V, G) = U_C(C_1, V, G) + U_{CC}(C_1, V, G)(C_2 - C_1).$$

Dividing these two approximations by $U_C(C_2, V, G)$ and $U_C(C_1, V, G)$ respectively and using eq. (2.9) together with the fact from eq. (2.1) that $C_1 - C_2 = \theta E$, we derive

$$r(C_1) = \frac{\mu}{\pi p \theta E} \qquad \text{and} \qquad r(C_2) = \frac{\mu}{(1-p)\theta E}, \tag{2.20}$$

where the tax evaded E is assumed to be positive.[18] The absolute risk aversion at each of C_1 and C_2 is determined only by the tax evaded E as a endogenous variable and two enforcement policies p and $\theta = 1 + \pi$ as exogenous parameters.[19] Substituting the two absolute risk aversions into eq. (2.19) and using again the fact that $dC_1 = dY - dR + dE + dC_0$ and $dC_2 = dY - dR - \pi dE + dC_0$, we have

$$dE = -\left(\frac{\mu}{\sigma + \mu^2}\right)(dY - dR + dC_0), \tag{2.21}$$

where $\sigma \equiv p(1-p)\theta^2$ represents the variance of one dollar evaded. On the right of eq. (2.21), the positive coefficient in the first parentheses measures the extent to

[17] Take the partial derivatives of eq. (2.9) with respect to V and G, and again, divide each of the two equations by eq. (2.9) to get $\frac{U_{CV}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CV}(C_2,V,G)}{U_C(C_2,V,G)}$ and $\frac{U_{CG}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CG}(C_2,V,G)}{U_C(C_2,V,G)}$ respectively.

[18] Even if $E = 0$ and thus $C_1 = C_2$, the two state-dependent marginal utility functions $U_C(C_1, V, G)$ and $U_C(C_2, V, G)$ are equal to the approximations respectively, and furthermore, eq. (2.19) is satisfied.

[19] Using absolute risk aversion term itself will add two additional parameters to our calculation and will make the numerical estimation harder.

which the taxpayers change the tax evaded when their incomes change. Since the mean and variance that the coefficient includes depend only on the audit rate p and fine rate θ, the degree of tax evasion in this economy is affected by the current state of tax enforcement. In addition, eq. (2.21) shows that the taxpayers reduce their taxes evaded when their disposable incomes get higher. Thus, the taxpayer responds to the fiscal reform in the opposite way; they evade more taxes if the government collects a revenue dR, but they evade fewer taxes if it transfers the revenue dC_0 back. Since $dY = wdL$, $dR = (1-\gamma)twdL + wLdt$, and $dC_0 = \beta e'\left(R_C\right)dR$, the change in tax evaded in eq. (2.21) can be rewritten as

$$dE = -\left[\frac{(\mu/\sigma)\left(1-(1-\gamma)t\left(1-\beta e'(R_C)\right)\right)}{1+(\mu^2/\sigma)\left(1-\beta e'(R_C)\right)}\right]wdL + \left[\frac{(\mu/\sigma)\left(1-\beta e'(R_C)\right)}{1+(\mu^2/\sigma)\left(1-\beta e'(R_C)\right)}\right]wLdt \tag{2.22}$$

in terms of the change in labor supply and average tax rate. Since both coefficients in the first and second square brackets are positive, the change in tax evaded is negatively related to the change in labor supply but positively related to the change in tax rate. If a government increases tax rates and this causes less labor supplies, then the taxpayers could evade much more. We do not conclude at this point, however, because it has not been figured out yet whether the higher tax rate has a negative effect on labor supply.

The next step is to evaluate the change dL in labor supply. Before doing so, we adopt the virtual income concept that [29] introduced first and [34] applied later. The concept is used in order to make linear budget constraints from the views of utility-optimizing individuals, even though the tax function is nonlinear.[20] In the

[20] See [34] for more detail.

context of tax evasion, the two state-dependent budget constraints in eq. (2.1) can be reformulated as $C_1 = (1-m)wL + E + Z$ for being caught in tax evasion and $C_2 = (1-m)wL - \pi E + Z$ for not being caught by applying a virtual income Z in the following form:

$$Z = Y - (1-m)wL - R + C_0. \tag{2.23}$$

Eq. (2.23) contains non-labor income $Y - wL$, the lump-sum transfer C_0, and the term $(m-t)wL$ generated by the nonlinear tax schedule. Since each taxpayer regards Z as exogenously given, the first order conditions in eqs. (2.4) - (2.7) and the two reformulated budget constraints give the function of labor supply as $L = L((1-m)w, p, \pi, G, Z)$. Therefore, after differentiating this function with respect to $(1-m)w$, G, Z, the change dL in labor supply becomes

$$dL = \frac{\eta L}{(1-m)w} d\left((1-m)w\right) + L_G dG + L_Z dZ, \tag{2.24}$$

where η is the uncompensated elasticity of labor supply with respect to the net wage $(1-m)w$. As in [45] and [34], the publicly supplied nonmarket good G is assumed to be tax-neutral at the margin, which implies that the marginal change dG does not directly affect labor supply, $L_G \equiv 0$, or the government tax revenue.[21] Using the expenditure function approach, Appendix A.1 shows that $\eta - (1-m)wL_Z = \eta^c$ in which the superscript c indicates 'compensated,' while no superscript implies 'uncompensated.' Using this fact and the assumption that $L_G = 0$, eq. (2.24) can

[21] This assumption is ensured when the private goods is weakly separable from the public good G in the expected utility function $\bar{U}$. For example, if the conventional utility function $U(C, V, G)$ is additive or multiplicative, then the expected utility function $\bar{U}(C_1, C_2, V, G, p) = (1-p)U(C_1, V, G) + pU(C_2, V, G)$ can satisfy the property.

be rewritten as follows:

$$(1-m)(1+\gamma\eta)dL = -\eta L dm - (\eta^c - \eta)dZ/w. \tag{2.25}$$

In addition, after differentiating eq. (2.23), the marginal change in virtual income Z is given as the following:

$$\begin{aligned} dZ &= (m + \gamma(1-m))\,wdL + wLdm - \left(1 - \beta e'(R_C)\right) dR - \beta e'(R_C)\,\mu dE \qquad (2.26) \\ &= \left[\gamma + (1-\gamma)\left(m - t\left(1 - \beta e'(R_C)\right)\right)\right] wdL + wL\left(dm - \left(1 - \beta e'(R_C)\right) dt\right) - \beta e'(R_C)\,\mu dE. \end{aligned}$$

Conducting the total differentiation until now leaves a system of three equations (2.22), (2.25) and (2.26) with three unknowns dE, dL and dZ. Substituting eq. (2.22) into eq. (2.26), and in turn, eq. (2.26) into eq. (2.25) implies the proportional change $\tilde{L}$ in eq. (2.27), in which the tilde above a variable (or parameter) represents a proportional change in the variable (or parameter).

Solving the three equations above simultaneously gives dL and dE in terms of exogenous parameters. Finally, substituting eqs. (2.22) and (2.27) into eq. (2.18), we derive the $\mathrm{MCF_T}$ for the tax reform in eq. (2.28)

$$\tilde{L} = -\frac{\left[\eta^c dm/dt - (\eta^c - \eta)\frac{(1+\mu^2/\sigma)(1-\beta e'(R_C))}{1+(\mu^2/\sigma)(1-\beta e'(R_C))}\right] dt}{(1-m)(1+\gamma\eta^c) + (\eta^c - \eta)\left[m - (1-\gamma)t\frac{(1+\mu^2/\sigma)(1-\beta e'(R_C))}{1+(\mu^2/\sigma)(1-\beta e'(R_C))} + \frac{(\mu^2/\sigma)\beta e'(R_C)}{1+(\mu^2/\sigma)(1-\beta e'(R_C))}\right]}, \tag{2.27}$$

$$\mathrm{MCF_T} = 1 + \frac{\left(\mu^2/\sigma + m\right)\eta^c dm/dt + \left[(\mu^2/\sigma)\left(a + b\eta^c dm/dt\right) - \left(\mu^2/\sigma + m\right)(\eta^c - \eta)\right]\left(1 - \beta e'(R_C)\right)}{a + b\eta^c dm/dt + (\mu^2/\sigma + m)\left((\eta^c - \eta) - \eta^c dm/dt\right)}, \tag{2.28}$$

where $a \equiv (1-m)(1+\gamma\eta^c)$ and $b \equiv m - (1-\gamma)\,t$.

The $\mathrm{MCF_T}$ is only measured in terms of exogenous parameters. As seen in eq. (2.18), $\mathrm{MCF_T}$ in eq. (2.28) also reduces to Mayshar's for $\mu^2/\sigma = 0$ (i.e., no tax evasion). It is possible to show that the $\mathrm{MCF_T}$ in eq. (2.28) is greater than Mayshar's (See the equation 17 in his paper) when $dm/dt > 1$.[22] This is logical because the existence of tax evasion makes the economic environment uncertain and, in turn, causes an additional burden to the economy. Our $\mathrm{MCF_T}$ includes both the labor supply distortion of tax and the risk bearing cost of tax evasion. In eq. (2.28), we see that $\mathrm{MCF_T}$ has a direct cost of one dollar plus an additional term representing the labor supply distortion and risk bearing cost together. [48] points out that the total excess burden of risk and tax distortion can be treated separately if utility function is separable in consumption and labor. We do not restrict the utility function to a specific form in our model. Therefore, risk bearing cost and tax distortion are interrelated in our model.

2.4 Enforcement reform

In the previous section, the government revises the nonlinear tax schedule for extra revenue to finance its additional expenditure. Even though the tax scheme is used as a common policy instrument, the government could employ the audit rate or the fine rate instead. For example, the IRS increased the audit rate on individuals with more than \$100,000 of income by 40% in 2004.[23] This kind of practice often attracts a new analysis on measuring the costs of enforcement policies. In addition, the analysis can allow one to compare the costs of enforcement and tax

[22]Note that $dm/dt > 1$ is a sufficient but not a necessary condition to show analytically that our $\mathrm{MCF_T}$ is greater than Mayshar's. [45] assumes that ratio of marginal tax rate and average tax rate is constant and greater than 1. In progressive tax system for a given income level average tax rate is always lower than the marginal tax rate. However, whether dm is greater than dt or not depends on how the tax system is changed.

[23]Give reference at http://www.nytimes.com/2004/11/19/business/19irs.html.

policies together. Hence, this section derives two different MCFs when a tax collection agency could use either the audit rate p or the fine rate θ in the enforcement mechanism ϕ_E. Although the two MCFs are derived separately at the end, we first consider the revision in both the audit and fine rate by some point in this section and then assume only the change in each of the enforcement policies from that point on. Following the same definitions and steps used in the section above, we continue to exploit total differentiation in order to investigate the effects of tax enforcement changes on individuals' welfare. Now, the enforcement reform and corresponding reform in spending $\{G, C_0, \phi_E\} \subset \Omega$ are desirable if total change in the taxpayer's expected utility is positive or equal to zero:

$$d\bar{U} = \bar{U}_{C_1} dC_1 + \bar{U}_{C_2} dC_2 + \bar{U}_V dV + \bar{U}_G dG + \bar{U}_p dp \geq 0. \tag{2.29}$$

Eq. (2.29) includes $\bar{U}_p dp$ as one more term than eq. (2.14). In contrast to the tax reform, the revision in audit rate could directly affect the taxpayer's utility function since the uncertainty of this economy has been generated by the government's random audits. Differentiate two state-dependent budget constraints of individuals in eq. (2.1), the market interest in eq. (2.12) and the expected revenue of government in eq. (2.13) to have $dC_1 = dY - dR + dE + dC_0$, $dC_2 = dY - dR - \pi dE - E d\pi + dC_0$, and $d\bar{R} = dR - \mu dE + (\theta E - h_p)\, dp + (pE - h_\theta)\, d\theta$. We know from the previous section that $dV = -dL$ and $dY = w dL$. Combining these indentities together with the first-order conditions in eq. (2.4) - (2.7) yields the following:[24]

$$\begin{aligned}&\frac{\bar{U}_G}{\lambda_1+\lambda_2}dG+dC_0 \qquad (2.30)\\&\geq d\bar{R}+\mu dE-mwdL+\left(h_p-\theta E-\frac{\bar{U}_p}{\lambda_1+\lambda_2}\right)dp+\left(h_\theta-pE+\frac{\lambda_2 E}{\lambda_1+\lambda_2}\right)d\theta.\end{aligned}$$

Eq. (2.30) implies that the marginal cost of enforcement reform on the right should be less than or equal to the marginal benefit of corresponding reform in spending on the left. The term $\bar{U}_p=-U\left(C_1,V,G\right)+U\left(C_2,V,G\right)$ can be approximated to $-U_C\left(C_2,V,G\right)\left(C_1-C_2\right)$ by the first-order Taylor expansion. Using this approximation together with eqs. (2.1), (2.5) and (2.6) and dividing each side of eq. (2.30) by $d\bar{R}>0$, we define the marginal benefit and cost of funds as

$$\begin{aligned}\text{MBF}&\equiv(1-\beta)g'(R_G)\frac{\bar{U}_G}{\lambda_1+\lambda_2}+\beta e'(R_C) \qquad (2.31)\\&\geq 1+\frac{\mu dE-mwdL+\left(h_p-\theta E+E/p\right)dp+\left(h_\theta-pE+E/\theta\right)d\theta}{d\bar{R}}\equiv\text{MCF}_\text{E},\end{aligned}$$

where the government is assumed again to spend the fraction β of its marginal expected revenue on the transfer. Compared to eq. (2.16), the marginal cost of funds is quite different, while the marginal benefit of funds is still same in eq. (2.31). Since there is no change in tax rates, $dR=(1-\gamma)twdL$. Thus, the marginal change in the government's expected revenue in eq. (2.13) becomes

$$d\bar{R}=(1-\gamma)twdL-\mu dE+\left(\theta E-h_p\right)dp+\left(pE-h_\theta\right)d\theta. \qquad (2.32)$$

[24]From eqs. (2.4), (2.5) and (2.7), $d\bar{U}=\lambda_1 dC_1+\lambda_2 dC_2+\left(\lambda_1+\lambda_2\right)\left(1-m\right)wdV+\bar{U}_G dG+\bar{U}_p dp$. Substitute $dC_1=dY-dR+dE+dC_0$ and $dC_2=dY-dR-\pi dE-Ed\pi+dC_0$ into this equation to get $d\bar{U}=\left(\lambda_1+\lambda_2\right)\left(dY-dR+dC_0+\left(1-m\right)wdV\right)+\left(\lambda_1-\pi\lambda_2\right)dE-\lambda_2 Ed\pi+\bar{U}_G dG+\bar{U}_p dp$. Since $dY=wdL$, $dV=-dL$, $d\bar{R}=dR-\mu dE+\left(\theta E-h'\left(p\right)\right)dp+\left(pE-i'\left(\theta\right)\right)d\theta$, $d\pi=d\theta$, and from eq. (2.6), $\lambda_1-\pi\lambda_2=0$, we have that $d\bar{U}=\left(\lambda_1+\lambda_2\right)\left[dC_0-d\bar{R}-\mu dE+mwdL+\left(\theta E-h'\left(p\right)\right)dp+\left(pE-i'\left(\theta\right)\right)d\theta\right]-\lambda_2 Ed\theta+\bar{U}_G dG+\bar{U}_p dp$. Finally, set $d\bar{U}\geq 0$, divide this inequality by $\lambda_1+\lambda_2$, and rearrange it to arrive at eq. (2.30).

After inserting eq. (2.32) into the right-hand side of eq. (2.31), the marginal cost of funds associated with the change in probability of detection p and fine rate θ becomes

$$\mathrm{MCF_E} = 1 + \frac{\mu dE - mwdL + E\left(ph_p/E - p\theta + 1\right)\tilde{p} + E\left(\theta h_\theta/E - p\theta + 1\right)\tilde{\theta}}{(1-\gamma)twdL - \mu dE + E\left(p\theta - ph_p/E\right)\tilde{p} + E\left(p\theta - \theta h_\theta/E\right)\tilde{\theta}}. \quad (2.33)$$

Through the same steps used in Section 4, we will evaluate the changes dL and dE in response to the reform. As the first step, the change in tax evasion dE is derived in terms of the change in labor supply dL. After taking the log and totally differentiating eq. (2.9), use the fact that $\frac{U_{CV}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CV}(C_2,V,G)}{U_C(C_2,V,G)}$ and $\frac{U_{CG}(C_1,V,G)}{U_C(C_1,V,G)} = \frac{U_{CG}(C_2,V,G)}{U_C(C_2,V,G)}$ to arrive at

$$r\left(C_1\right)dC_1 + \left(\frac{p}{1-p}\right)\tilde{p} = r\left(C_2\right)dC_2 - \tilde{p} - \left(\frac{\theta}{\pi}\right)\tilde{\theta}.$$

Plugging eq. (2.20) into eq. (2.19) with the fact that $dC_1 = dY - dR + dE + dC_0$ and $dC_2 = dY - dR - \pi dE - Ed\pi + dC_0$ gives

$$dE = -\left(\frac{\mu}{\sigma+\mu^2}\right)\left[(dY - dR + dC_0) + E\left(\frac{\sigma}{\mu^2}\right)\left(\left(1 - \frac{p\theta\mu}{\sigma}\right)\tilde{p} + \tilde{\theta}\right)\right]. \quad (2.34)$$

In eq. (2.34), the second term in square brackets shows that the changes in p and θ decrease the amount of tax evaded. This implies that both the audit and fine rate determine the existence as well as the degree of tax evasion. The enforcement policies directly affect the evasion, whereas the tax codes indirectly affect the evasion through the income change as in eq. (2.21).

From this point, we consider only the change in each separate enforcement policy. The government is assumed to revise either of two enforcement policies p

and θ. Let us introduce a function that makes both of the analyses simple. For $k \in \phi_E$, the function ξ_k is defined by

$$\begin{cases} \xi_p = p\theta\mu/\sigma & \text{if } dp \neq 0 \text{ and } d\theta = 0, \\ \xi_\theta = 0 & \text{if } d\theta = 0 \text{ and } d\theta \neq 0. \end{cases}$$

Then two separate analyses can be united because they have perfect symmetry except for the term that ξ_k implies. The second term in square brackets in eq. (2.34) points out the only difference between two separate reforms. A revision in audit rate directly reformulates individuals' preference orderings, since the audit rate as a policy parameter generates the uncertainty in this economy. Therefore, based on the fact that $dY = wdL$, $dR = (1-\gamma)twdL$, and $dC_0 = \beta e'(R_C)\, dR$, the change dE for each of the two reforms becomes

$$dE = -\left[\frac{(\mu/\sigma)\left(1-(1-\gamma)t\left(1-\beta e'(R_C)\right)\right)}{1+(\mu^2/\sigma)\left(1-\beta e'(R_C)\right)}\right] wdL - E\left[\frac{(1-\xi_k)/\mu + (\mu/\sigma)\left(p\theta - kh_k/E\right)\beta e'(R_C)}{1+(\mu^2/\sigma)\left(1-\beta e'(R_C)\right)}\right]\tilde{k}. \tag{2.35}$$

Next, we evaluate the change in labor supply dL by replicating the steps employed in the previous section. Totally differentiating the labor supply function $L = L((1-m)w, p, \pi = \theta - 1, G, Z)$ yields

$$dL = \frac{\eta L}{(1-m)\, w} d\left((1-m)\, w\right) + \varepsilon_k L\tilde{k} + L_G dG + L_Z dZ, \tag{2.36}$$

where ε_k is the uncompensated elasticity of labor supply with respect to the enforcement policy $k \in \phi_E$. Again, using the assumption that G is tax-neutral at the margin and totally differentiating the virtual income in eq. (2.23) respectively, the total effects dL and dZ become the following:

$$(1-m)(1+\gamma\eta)\, dL = (1-m)\, L\varepsilon_k\tilde{k} - (\eta^c - \eta)\, dZ/w, \tag{2.37}$$

$$dZ = (m + \gamma (1 - m)) wdL - \left(1 - \beta e'(R_C)\right) dR - \beta e'(R_C) \left(\mu dE - E (p\theta - kh_k/E) \tilde{k}\right) \tag{2.38}$$

$$= \left[\gamma + (1 - \gamma) \left(m - t \left(1 - \beta e'(R_C)\right)\right)\right] wdL - \beta e'(R_C) \left(\mu dE - E (p\theta - kh_k/E) \tilde{k}\right).$$

Finally, as in the previous sections, three equations (2.35), (2.37) and (2.38) yield the change in labor supply and the $\mathrm{MCF_E}$ as

$$\tilde{L} = \frac{\left[(1-m)\,\varepsilon_k - (\eta^c - \eta)\varphi\left(1 - \xi_k + (1 + \mu^2/\sigma)\,(p\theta - kh_k/E)\right) \frac{\beta e'(R_C)}{1 + (\mu^2/\sigma)(1 - \beta e'(R_C))}\right] \tilde{k}}{(1-m)\,(1 + \gamma\eta^c) + (\eta^c - \eta)\left[m - (1-\gamma)t\frac{(1+\mu^2/\sigma)(1-\beta e'(R_C))}{1+(\mu^2/\sigma)(1-\beta e'(R_C))} + \frac{(\mu^2/\sigma)\beta e'(R_C)}{1+(\mu^2/\sigma)(1-\beta e'(R_C))}\right]}, \tag{2.39}$$

$$\mathrm{MCF_{E(k)}} = 1 - \frac{\left\{ \begin{array}{c} (1-m)\left(\mu^2/\sigma + m\right)\varepsilon_k^c + \varphi c_k a \\ + \left[\left(\mu^2/\sigma\right)\left((1-m)\,b\varepsilon_k^c - \varphi a\right) + (\eta^c - \eta)\,\varphi\left(\left(\mu^2/\sigma + m\right) + c_k b\right)\right](1 - \beta e'(R_C)) \end{array} \right\}}{(1-m)\,(\mu^2/\sigma + (1-\gamma)\,t)\,\varepsilon_k + \varphi\,(1 + c_k)\,(a + (\eta^c - \eta)\,b)}, \tag{2.40}$$

where $\varphi \equiv E/wL = -(1-m)(\varepsilon_k^c - \varepsilon_k)/(\eta^c - \eta)$ for $k \in \phi_E$ and $c_k \equiv (1 + \mu^2/\sigma)(p\theta - kh_k/E) - \xi_k$.

In a world with tax evasion and positive tax rates there are two different sources of deadweight loss (or inefficiency). One is distorted labor supply because of labor tax. The other is the risk cost of evading tax. If we assume that wage, audit and fine elasticity of labor supply are greater than zero (η, ε_p, and $\varepsilon_\theta > 0$), then the following results hold. Increasing tax rates (tax reform) causes a decrease in labor supply and an increase in tax evasion ($dL < 0$ and $dE > 0$) as can be seen in the above equations. Hence, tax reform worsens preexisting tax distortions. $\mathrm{MCF_T}$ has a direct resource cost of one dollar as well as additional deadweight loss. Thus, $\mathrm{MCF_T}$ is greater than 1. However, enforcement reform (i.e., increasing audit or fine rate) causes an increase in labor supply and a decrease in tax evasion ($dL > 0$ and $dE < 0$). This means preexisting distortions caused by tax are lowered by enforcement reform.

MCF_E has a direct cost of one dollar, marginal resource cost of enforcement, and negative deadweight loss. For this reason, when the enforcement reform is costless or has a sufficient low cost, MCF_E can be less than one. Enforcement could actually be a very useful policy, if costs associated with increasing audit or fine rates are low. Increasing enforcement will lower preexisting distortions and yield more extra revenue. The government can then use the revenue to lower other distortionary taxes. This argument is very similar to the double-dividend hypothesis of [11].[25] The first dividend is decreased labor supply and tax evasion distortions while the second dividend is obtained by using tax revenue to lower some distortionary taxes.

If extra revenue from either enforcement or tax reform is used in the same way, and the enforcement has a low marginal resource cost, MCF_T is greater than one while MCF_E is less than one. In this case, the enforcement reform is superior to tax reform. In that sense, tax reform and enforcement reform are complements rather than substitutes in terms of efficiency. In other words, a tax reform increases the excess burden while an enforcement reform decreases excess burden in the economy. Thus, a tax reform should be accompanied by an enforcement reform to minimize the extra burden caused by tax reform. A very high marginal cost for enforcement or negative enforcement elasticity of labor supply may indeed cause tax and enforcement reform to be substitutes.

Government can increase enforcement in two ways. It can increase the audit

[25] Double-dividend is the notion that environmental taxes can both reduce pollution (the first dividend) and reduce the overall economic costs associated with the tax system by using the revenue generated to displace other more distortionary taxes that slow economic growth at the same time (the second dividend).

or fine rates. It is not easy to see which enforcement policy has a lower MCF from the above equations. However, the terms c_p, c_θ, ε_p, and ε_θ play an important role in determining the magnitude of MCFs. Therefore, by comparing these terms, we can say which policy has lower MCF. We mentioned above that probability and penalty elasticities of labor supply mainly determine the response of labor supply, dL, and it is positive if ε_p and $\varepsilon_\theta > 0$. The bigger the elasticity, the greater the labor supply response. Therefore, a higher elasticity means a higher decrease in tax distortion and a lower MCF. The marginal cost of increasing the audit and fine rates is included in the terms c_p and c_θ. As marginal cost of enforcement (audit and fine) increases, both MCF_p and MCF_θ increase. Everything the same, the enforcement policy that has higher elasticity of labor supply and lower marginal cost will have a smaller MCF. We can also say that the audit and fine rates are substitutes for each other in terms of efficiency of policy. They both decrease preexisting labor supply distortion (conditional on ε_p and $\varepsilon_\theta > 0$) and yield extra government revenue.

2.5 Numerical analysis

In this section, we calculate MCFs for alternative policies numerically. To estimate $\mathrm{MCF_T}$, we need values for 8 parameters: η^c, η, t, m, dm/dt, γ, β, p, θ. In Table 2.1, [45] suggests the following benchmark parameters for U.S. economy: $\eta = 0$, $\eta^c = \eta - .2$, $\gamma = .28$, $m = .427$, $m/t = dm/dt = 1.564$. In addition, we assume for now that $\beta = 0$. To find values for audit rate p and fine rate θ, we first solve the model for a specific utility function. Then, to find proper values for audit and fine rates, we match the tax evasion ratio that our model estimates with the real world tax evasion ratio, 17%.[26] We assume separable CRRA utility function

$$U(C,V) = \frac{C^{1-\delta}}{1-\delta} + \frac{V^{1-\epsilon}}{1-\epsilon}, \tag{2.41}$$

where V is leisure and we normalize time endowment to 1 so that $V = (1 - L)$. We assume utility function parameters δ and ϵ are equal to 2. We solve our model with specified utility function and given parameter values. Equilibrium values of labor supply and tax evasion imply that when $p = .38$, $\theta = 2$, the tax evasion ratio is 17%.[27] To estimate $\mathrm{MCF_E}$, we need values for ε_p, ε_θ, h_p, h_θ, and E more. In other words, we need labor supply elasticity with respect to audit and fine rate, marginal resource cost of audit and fine rate, and the amount of evasion. We find E, ε_p and ε_θ from the solution of our model with utility function above.[28]

In Table 2.2, we compare our $\mathrm{MCF_T}$ estimates with those of [34] for different government policy and individual parameter values. We analytically showed above that our $\mathrm{MCF_T}$ estimate is greater than Mayshar's. The estimates in the first column are based on our $\mathrm{MCF_T}$ formula. The second column estimates are based on Mayshar's formula. In the first row of Table 2.2, we present $\mathrm{MCF_T}$ estimation for different values of β. When $\beta = 0$, no government revenue is transferred to taxpayers, and when $\beta = 1$, all tax revenue is transferred to taxpayers. We see

[26]IRS estimate of tax evasion for 2001 is 17%. U.S department of Treasury, Internal Revenue Service (2006)

[27]There many values for p and θ that gives 17% evasion rate. We fix penalty rate to 1 and get $p = .38$. IRS penalty rate for tax evasion varies between 25% and 75% depending on the nature of the tax underpayment, so fixing penalty rate to 1 makes sense.However, auditing rate in the US is much lower than 38%. In the real world auditing rate is not exogenous to taxable income. Also it is much harder for wage earners to evade compared to self employed. Since our model does not consider this aspect of tax evasion, 38% auditing rate seems reasonable.

[28]Tax evasion is .04, labor supply is .56 and taxable income is .23 in equilibrium in our model. Note that we normalize time endowment and wage to 1.

Table 2.1: Benchmark parameters for the U.S. economy

Stuart (1984)	:	$\eta = 0$
		$\eta^c = \eta - .2$
		$\gamma = .28$
		$m = .427$
		$m/t = dm/dt = 1.564$
Baseline	:	$\varepsilon_p = \varepsilon_\theta = 0$
		$\beta = 0$
		$h_p = h_\theta = 0$
Model	:	$\theta = 2$
		$p = .38$
		$E = .04$

that our $\mathrm{MCF_T}$ estimate is greater than Mayshar's no matter how the extra tax revenue is spent by the government. In the second row, we change the marginal tax rate, while in the third and fourth row we change audit and fine rates respectively. It is not surprising that a higher marginal income tax rate leads to higher $\mathrm{MCF_T}$ for both our estimate and Mayshar's. However, only labor supply is distorted in Mayshar's case, while both labor supply and tax evasion are distorted in our case. More enforcement (higher audit and fine rates) means less $\mathrm{MCF_T}$ because more enforcement causes less evasion in equilibrium. In the third row, for $p = .45$, our $\mathrm{MCF_T}$ estimate is very close to Mayshar's since people have almost no incentive to evade when $p = .45$ (expected return on evading, $1 - p\theta$, is still positive but very close to 0). We change labor supply elasticity in the fifth row. As elasticity increases, labor supply distortion of a tax increase becomes more severe, and this leads to higher $\mathrm{MCF_T}$ for both our and Mayshar's model.

Table 2.3 compares the MCFs for three alternative revenue-raising policies

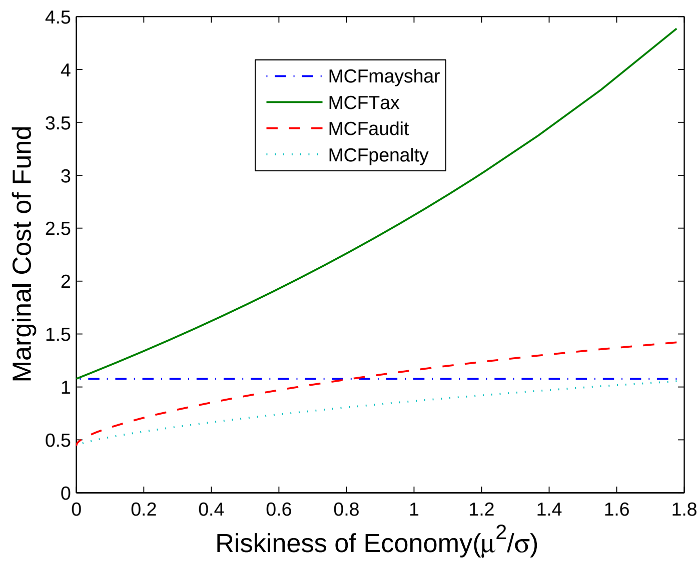
Table 2.2: $\mathrm{MCF_T}$ with tax evasion versus without tax evasion

	$\mathrm{MCF_T}$	
	Tax evasion	No tax evasion
Benchmark case	1.155	1.076
Government policies		
1. Share of marginal revenue		
$\beta = .618$	1.210	1.160
$\beta = 1$	1.244	1.211
2. Marginal tax rate		
$m = .350$	1.131	1.055
$m = .460$	1.167	1.087
3. Audit rate		
$p = .2$	1.870	1.076
$p = .45$	1.070	1.076
4. Fine rate		
$\theta = 2.3$	1.092	1.076
$\theta = 2.6$	1.078	1.076
Taxpayer		
5. Net-wage-rate elasticity		
$\eta = .318$	1.641	1.447
$\eta = .5$	1.986	1.687

(tax, audit, and fine rates), depending on different government policy and taxpayer parameters. In general, $\mathrm{MCF_T}$ is greater than MCF_p and MCF_θ in Table 2.3. Audit and fine rates (p, θ) determine the riskiness of tax evasion (μ^2/σ). More riskiness means that the risk cost of evading tax is greater. Hence, as seen in the third and fourth rows, either an increase in p and θ increases MCFs, raising the riskiness of tax evasion. A higher marginal resource cost of tax enforcement (h_p, h_θ) means higher MCF_p and MCF_θ. In fifth row, when $h_p = h_\theta = 5$, MCF_p and MCF_θ are 1.754 and 1.423 respectively, while $\mathrm{MCF_T}$ is 1.155. Therefore, if increasing enforcement marginally is costly, then tax reform has a lower marginal cost compared to enforcement reform. Elasticities of labor supply also play a key role in determining the magnitude of MCFs for different policies. In the 7th row, when $\varepsilon_p = \varepsilon_\theta = -.5$, MCF_p and MCF_θ are greater than MCF_T. MCF_p and MCF_θ are 1.397 and 1.189 respectively, while MCF_T is 1.155. Elasticities have an opposite effect on MCF_T and MCF_E. While higher wage elasticity (η) causes more labor supply distortion in the tax reform case, higher enforcement elasticities (ε_p, ε_θ) mean less tax distortion for labor supply in the enforcement reform case.

In Figure 2.1, we graph MCFs for different values of μ^2/σ when $\beta = 0$, $h_p = h_\theta = 0$. In our formulation of MCFs above, the term μ^2/σ represents the riskiness of tax evasion. Note that μ is the expected return on evading one dollar and σ is variance of return. As the audit rate or fine rate goes down, μ increases while σ decreases, and thus, overall μ^2/σ increases. In other words, when auditing becomes less common or when fines on evasion are lower, expected return on tax evasion will be greater, and taxpayers will evade more in equilibrium. Thus, the taxpayers' response dE to a policy reform will be higher (since expected return is higher), leading to more distortion. MCF_T is greater than MCF_E for all values of μ^2/σ, since the enforcement is assumed to be costless. Figure 2.2 shows how MCF_E changes as marginal resource cost of enforcement (h_p, h_θ) increases. When the enforcement policy to deter evasion becomes more costly, MCF_E increases tremendously. This is trivial because our MCF_E includes the resource cost of increasing tax enforcement as well as labor supply distortion and risk-bearing cost. Thus, when policymakers decide which policy to use to raise additional tax revenue, they need to analyze carefully how much increasing tax enforcement costs. In Figure 2.3 , we see how MCFs change with public spending policy. As β increases, all MCFs go up. When

Figure 2.1: MCFs and riskiness of tax evasion



$\beta = 1$, extra tax revenue is returned to individuals. This compensates the income effect of the tax or enforcement reform. As a result, when β goes up, labor supply distortion increases, causing MCFs to go up as well.

Figure 2.2: MCFs and marginal resource cost of tax enforcement

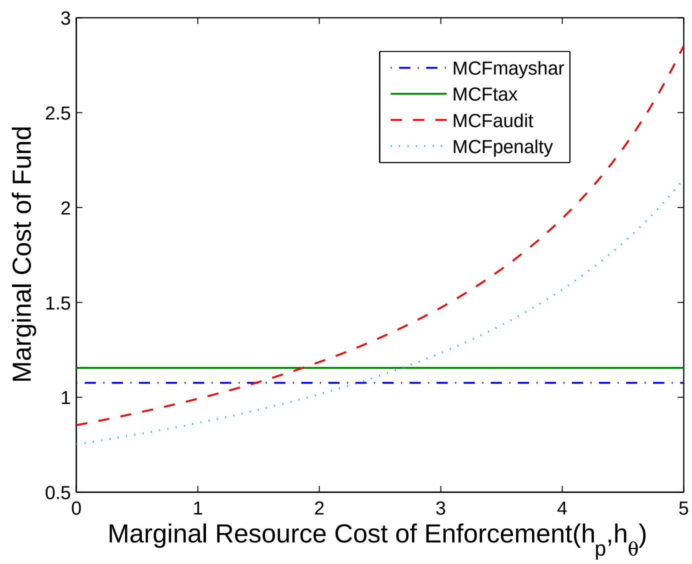
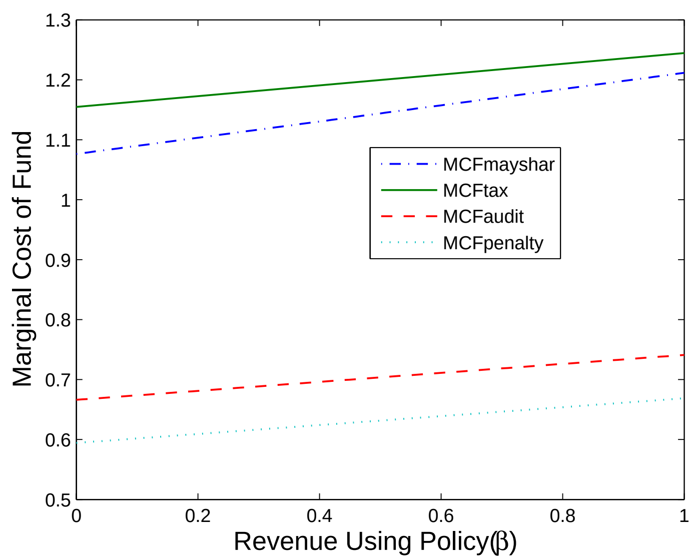


Figure 2.3: MCFs and public spending policy



2.6 Conclusion

In a general equilibrium of tax evasion, we analytically derive three MCFs for the nonlinear tax, audit, and fine rates. Ignoring the tax evasion behavior will underestimate the $\mathrm{MCF_T}$. In a world with tax evasion, individuals could get more welfare loss from both tax distortion and uncertainty introduced by tax evasion. When calculating $\mathrm{MCF_T}$, taking the risk-bearing cost of evasion into account will give more accurate estimates. Thus, governments should consider the risk-bearing cost of tax evasion while deciding on publicly funded projects. [4] argues that tax evasion can cause another type of burden because of inefficient allocation of resources by taxpayers who try to evade. Even though the $\mathrm{MCF_T}$ estimates in this paper are always greater than in [34] and [45], they are highly dependent on values assigned to audit and fine rate, however.

Governments can also use audit rate or fine rate in addition to tax rate as a policy tool. Considering efficiency cost of each policy is important when a government decides how to collect additional tax revenue. Our calculations show that, compared to a tax reform, an enforcement mechanism generates a lower MCF if the marginal resource cost of enforcement is low. However, when audit and fine elasticities of labor supply are negative and the marginal resource cost of using these policies is high, then the tax reform might have a lower MCF than the enforcement reform. In addition, it may not always be feasible to use enforcement policies in practice. For example, higher income individuals or some firms may lobby to government not to increase audit rate or penalty rate on tax evasion. Thus, using audit or fine rate might have some additional costs to a society in terms of effort and time spent in passing bills in congress. Our model does not cover this aspect of the economy. The magnitudes of MCFs are mainly determined by elasticities of labor supply and marginal costs of enforcement policies in our model. Our model suggests that when enforcement is costless or has a low cost and labor supply elasticities are positive, using enforcement as a policy tool is superior to a tax reform. Furthermore, when a government increase a tax rate, increasing enforcement neutralizes the extra distortion caused by the increased tax rate.

Table 2.3: MCFs with tax evasion for alternative revenue-raising policies

	$\mathrm{MCF_T}$	MCF_p	MCF_θ
Benchmark case	1.155	.657	.587
Government Policies			
1. Share of marginal revenue			
$\beta = .618$	1.210	.704	.633
$\beta = 1$	1.245	.733	.662
2. Marginal tax rate			
$m = .35$	1.131	.657	.587
$m = .46$	1.167	.657	.587
$m = .35$ ($\beta = 1$)	1.183	.703	.633
$m = .46$ ($\beta = 1$)	1.276	.748	.676
3. Audit rate			
$p = .2$	1.870	1.250	.961
$p = .45$	1.070	.555	.529
4. Fine rate			
$\theta = 2.5$	1.065	.521	.513
$\theta = 3$	1.033	.453	.469
5. Marginal resource costs of audit and fine rate			
$h_p = h_\theta = .5$	1.155	.674	.624
$h_p = h_\theta = 2$	1.155	.877	.767
$h_p = h_\theta = 5$	1.155	1.754	1.423
Taxpayer			
6. Net-wage-rate elasticity			
$\eta = .318$	1.641	.657	.587
$\eta = .5$	1.986	.657	.587
$\eta = .318$ ($\beta = 1$)	1.725	.725	.654
$\eta = .5$ ($\beta = 1$)	2.060	.720	.650
7. Audit- and fine-rate elasticities			
$\varepsilon_p = \varepsilon_\theta = -.5$	1.155	1.397	1.189
$\varepsilon_p = \varepsilon_\theta = .5$	1.155	.433	.366

Chapter 3

Effect of Tax administration Reforms and Audits on Tax Evasion in Turkey

3.1 Introduction

Effective collection of tax revenues is a prerequisite for a healthy economy. A nation's plan for economic development will fail if the government lacks the means to collect funds mandated by that plan. Low tax compliance is a matter of serious concern in many developing countries, which limits the capacity of their government to raise revenues in order to finance government expenditures. Economic theory suggests that tax compliance depends on the enforcement policies of the tax authorities, income, tax rates, and individuals' tastes and preferences. Governments use various enforcement policies to increase taxpayer compliance. Tax audits are one of the most common enforcement mechanisms used to increase compliance of taxpayers. Reforming certain aspects of the tax administration represents an alternative way to increase voluntary compliance. The critical question, therefore, is to what extent would tax payers alter their compliance behavior in response to different policy alternatives.

This paper studies the effects of tax audits and tax administration reform on tax evasion. First, I study the effect of the audit coverage on tax evasion by allowing the endogeneity of audits and controlling for detectibility and other sociodemographic variables. I use panel data from 2003 to 2007 from 81 provinces in Turkey. The data includes reported income, reported tax lability, number of tax returns, average level of income, number of audits, number of negotiations between tax-payer and tax office and number of tax office workers, all at the province level, as well as the sociodemographics of the province. Second, I focus on the reform in tax administration that took place in Turkey in 2005. The reform encompassed institutional improvements, automation, transparency, compliance, taxpayer services and audits. Presidency of Tax Administration (P.T.A), which previously operated under ministry of finance, gained partial autonomy under the reform. After the reform, P.T.A had responsibility for the internal organization of tax operations, including the size and geographical location of tax offices; and the discretion to formulate and implement strategic and operational plans. Also, P.T.A were given the ability to recruit and fire staff, in accordance with public sector policies and procedures; the ability to establish and operate staff training/development programmes; and the ability to negotiate staff remuneration in accordance with broader public sector-wide policies. For the first time, functions such as taxpayer services, auditing, and strategic planning were introduced and organized both at the headquarters and at the local level. In 29 provinces, a special tax office called the Tax Office Directorate (T.O.D.) was established in order to realize these reforms. Specifically, T.O.D.s were established to increase the quality of taxpayer services, to conduct strategic planning for audits and to find non-registered individuals and register them. I test whether T.O.D.s met their goal. Specifically, I analyze the effect of the reform by using the 29 provinces in which a T.O.D. is established as a treatment group and the other 51 provinces as the control group. In other words, I investigate whether establishing special tax units to increase taxpayer services and audit quality has a significant effect on compliance at the province level.

Several studies analyze the effect of tax audits on tax compliance empirically. Many of these studies use Taxpayer Compliance Measurement Program (TCMP) data from the U.S.A.[1] The TCMP data consists of line-by-line information about what the taxpayer reported, and what the examiner concluded was correct. Dubin and Wilde (1988) analyzes the effect of federal income tax auditing on compliance at the three-digit zip-code level. For low- and middle-income non-business returns, Dubin and Wilde find significant deterrent effects of audits on compliance. Beron, Tauchen, and Witte (1992) also studies the effect of audits and socioeconomic variables on compliance at three-digit zip-code level. They use tax return data and audit data for 1969 to estimate the effect of audits on compliance. Their measure of compliance is aggregate reported income and aggregate tax liability. Using a simultaneous equation model with equations for taxpayers' reports and for probability of audits, they find significant deterrent effect of audits for low-income returns with standard deductions. However, their results are very sensitive to model specification. Slemrod, Blumenthal and Christian (2001) conducted a more recent study about tax compliance and audit. They focused on the effects of increased audit probability on tax compliance. In 1995, a group of 1724 randomly selected Minnesota taxpayers were informed by letter that the returns they were about to file would be 'closely

[1]Some of the prominent studies that use TCMP data are: Nagin (1989), Feinstein (1991), and Clotfelter (1983)

examined.'[2] By using the tax returns of tax payers who received the letter and those who did not, Slemrod et al. analyzes this controlled experiment which is designed to learn about the impact of an increased probability of audit. They find that a heightened threat of being audited increases reported income and tax liability for low- and middle-income taxpayers. Pommerehne and Weck-Hannemann (1996) study the income tax non-compliance in Switzerland by using aggregated data from 25 cantons for 3 different years. They find that the probability of detection and the penalty tax rate seem not to exert a significant deterrent effect on income concealing. Also, in their study the marginal tax rate has a positive, whereas low-income allowances have a negative impact on noncompliance. Acconcia, D'Amato and Martina (2003) analyzes theoretically the interactions between evasion, corruption and monitoring as well as their adjustment to a change in the institutional setting. In their model taxpayers can bribe the auditors while a monitoring agency monitors bribing with a certain probability. They find that in equilibrium, the effects of a tougher deterrence policy, reduces evasion, whereas its effect on corruption is ambiguous.

The trend in modern tax administration is a strong focus on taxpayers, specialization of personnel, independence from the ministry of finance and privatization of activities which can be better performed by the private sector. Tanzi and Pellechio (1995) points out the five basic elements of a tax administration reform; Firm and continuous political commitment, a staff capable of concentrated work over a long period, a well defined and appropriate strategy, personnel training and education, and change in the motivation of taxpayers and tax administration. Andic

[2] 'Closely Examined' is the exact phrase they used in the letter.

(1994) claims that special taxpayer services that help, inform and educate individuals increase taxpayers' trust in the tax system. He also claims that special taxpayer services lead to reducing compliance costs and improving the level of tax compliance. Despite the fact that many developing countries have had reforms in their tax administrations in the past decades, empirical works on the relationship between the design of tax enforcement agencies and tax compliance are limited due to data availability. However, there are a few studies that analyze different aspects of tax administration reforms in different countries. Das-Gupta, Ghosh and Mookherjee (2004) examine the tax administration reform in staff assignment and compliance in India. Using the data from 49 local tax units over two years from three major cities in India, they find that significant compliance gains would accrue from expanded staff employment and changes in assignments procedures for both staff and taxpayers. Even though Das-Gupta et al. present a structural model that allows for self-selection of taxpayers into different tax units, the size of the data is very small. Kahn, Silva and Ziliak (2001) studies the effects of a performance-based wage system for tax administration staff. They use panel data from the Brazillian tax collection authority to examine the effects of a major incentive reform instituted in 1989 to improve tax enforcement. They find that the growth in fines per inspection after the reform is about 75% above what it would have been without reform. However, their analysis is limited to the effect of the reform on fines collected. They do not investigate the effect of the reform on taxpayer compliance.

This work contributes to existing empirical tax evasion literature in several ways. First, there are only a few empirical studies of tax compliance for developing countries. Some characteristics of developing countries, such as a large unregistered economy and bureaucratic inefficiency may cause tax evasion analysis in developing countries to be different than those in developed countries. I specifically focus on data from Turkey to analyze the compliance behavior of taxpayers. The data set that I chose to use is panel data from years 2004 through 2007, which allows me to take advantage of both regional and time variation in the number of audits. In other words, while Tauchen et al. (1992) and Dubin and Wilde (1988) use regional variation only, I use both regional and time variation for the number of audits. Using panel data is especially important if taxpayers make their tax reporting decisions based on audit probability from this year as well as from previous year. Second, I control for the detectibility of an audit. Given that a tax return is audited, the probability of detecting tax evasion can vary depending on the quality of auditor and the efficiency of local tax office. The province specific detection rate allows me to use the variation in audit quality between provinces. Third, wage and salary earners are not supposed to file a tax return in Turkey. When using aggregated data, this gives us some degree of flexibility since we do not have to worry about the type of the tax return (i.e wage income vs. business income). Finally, I analyze the effects of institutional reforms of tax administration in Turkey. In 29 provinces, T.O.D.s were established to increase taxpayer service and carry out strategic auditing. Many other developing countries are planning to reform their tax administration partly or fully to make them more efficient. Analyzing the implications of this specific reform can help policymakers to make a better decision about tax administration reforms in general.

I find that audits have a strong positive effect on reported income and tax liability. The effectiveness of audits is the same for reported income and tax liability. The reason for this is that the income tax system in Turkey is not as complex as the income tax system in U.S.A. There is almost a perfectly linear relationship between reported income and reported tax liability denoting that there is very less scope for deductions. Increasing the quality of an audit is also found to reduce tax evasion significantly. However, it is not as effective as increasing the audit coverage. I also find that the unemployment rate, which tends to have no direct impact on auditing, has dramatic effects on reported income and reported tax. This is because unemployment is generally associated with low tax base. The reform in the tax administration (i.e establishing T.O.D.s) had no significant effect on taxpayer compliance. However, the number of tax returns increased considerably during the post-reform period. This suggests that tax reform had an effect at the extensive margin rather than at the intensive margin. In other words, existing taxpayers did not change their compliance behavior, yet more individuals started to file tax returns. This is due to the increased efforts of T.O.D.s to register more taxpayers.

The remainder of this paper is organized as follows: Section 2 of this paper summarizes the tax system in Turkey and data characteristics. Section 3 presents a model of tax evasion and estimation results. Section 4 investigates the effects of tax administration reform (i.e establishing T.O.D.s). Section 5 concludes with some comments on the policy implications of my results.

3.2 Turkey's Tax System and Data

Before explaining the details about the data, it is worth mentioning some facts about the Turkish tax system in general. The tax regime in Turkey can be classified under three main categories: income tax, taxes on expenditures, and taxes on wealth. All three types of tax rates are set by the government and collected by local tax offices. Income tax also falls into two different categories: personal income tax and corporate income tax. The data in this study comes from personal income tax returns only. The income tax scheme is progressive, with marginal tax being 15% for the lowest income bracket and 35% for the highest income bracket. An individual whose income is earned only from a wage is not obligated to file an annual return. The employer deducts tax from the employee and transfers it to the tax authority every month. Taxes withheld at the source are declared to the tax office by the evening of the 20th day of the following month. Other individuals whose income is earned through commercial activities, agriculture, capital investment (interest and dividends), immovable assets and rights, and miscellaneous income and earnings are required to file a tax return. The annual tax return for these individuals is due each calendar year by the 15th day of the March of the following year.

After the tax returns are filed and delivered to the tax office, some tax returns are scheduled for audit. The rest of the auditing procedure is as follows. The taxpayer is notified by tax office of an audit. The auditor meets with the taxpayer to see the taxpayer's required paperwork. After auditing the tax return, if the auditor finds no difference between the reported income and his own finding, then the audit ends. If the auditor finds that the taxpayer has underreported his true income, a new tax amount and a fine is billed to the taxpayer.

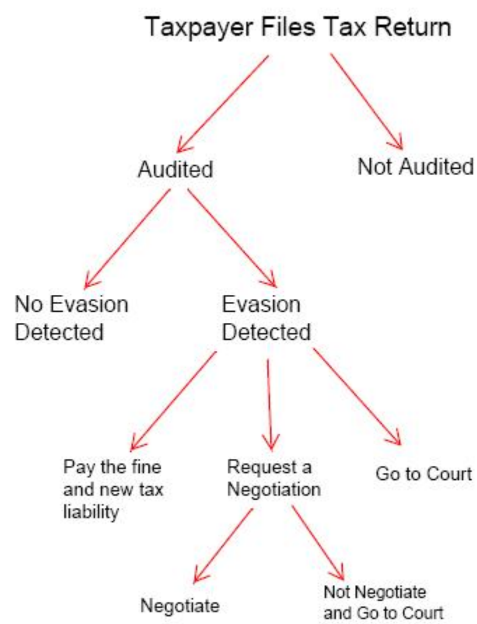
The taxpayer has three options at this stage: He can choose to pay the additional tax and fine, he can request a negotiation with tax office, or he can go to court. Requesting a negotiation with the tax office means that the taxpayer accepts that he underreported his income, but he disagrees with the amount of underreporting and the fine. Most of the time, the tax office reduces the tax liability and the fine amount during a negotiation so that the taxpayer will agree to pay them. The reason for giving underreporting taxpayers a negotiation option is to discourage them from going to court. By doing so, the tax office collects the tax liability and fine sooner. The P.T.A. reports that about 90% of negotiations result in an agreement[3]. If the negotiation process ends without agreement, then the taxpayer may go to court. Figure 1 depicts the auditing process in Turkey.

There are 81 provinces in Turkey, and within these provinces there are counties. The number of counties in each province varies depending on the population and the geographic characteristics of that province. Local jurisdictions have no right to set different taxes or to change the tax rates set by the government. In each county, tax offices are responsible for collecting all types of taxes and pursuing audits.

For the purpose of this study, I use data from two different sources: the Presidency of Tax Administration of Turkey and household budget surveys. Provincial data includes the number of audits, reported tax, reported tax liability, number

[3] See annual report of Presidency of Tax Administration. www.gib.gov.tr/fileadmin/user_upload/yayinlar/2006_Faaliyet_Raporu.pdf

Figure 3.1: Auditing Process



of negotiations, number of tax returns, and number of tax office workers, which was taken from the Presidency of Tax Administration data of 2003 through 2007. Tax return data comes from individual income taxpayers whose income is not from wages and salaries, since wage and salary earners do not have to file an annual income tax return. The number of tax office workers refers to the total number of tax office workers in a province. Household budget surveys provide province data from 2003 to 2007 on unemployment levels, education levels, income levels and the percent of individuals who do not have health insurance. For 2007, I combine 2003-2006 household budget survey data and use it to project 2007 values.

3.3 Effect of Audits on Compliance

3.3.1 Model

Let i denote the province, and t the year. Taxpayers differ with respect to their taxable income y; each taxpayer privately knows his own income and is assigned to a given province. The distribution of income for the set of taxpayers assigned to province i in year t is denoted by $F_{it}(y)$. Taxpayers are identical in all other respects; specifically, they share a common constant relative risk aversion utility function defined over their after-tax income: $c : u(c) = \frac{1}{\alpha}c^{\alpha}$, where $\alpha < 1, = 0$, with the case $\alpha = 0$ corresponding to $logc$. The tax law prescribes a constant tax rate τ lying between 0 and 1 and a constant penalty rate f on tax evasion established in an audit (and upheld in case the taxpayer appeals)[4]. Alternatively, if the taxpayer pays a bribe to the auditor in order to avoid paying the legal penalty, f can be interpreted as the bribe rate. From the taxpayer's standpoint, any payments that have to be made in the event of discovery of tax evasion by the auditor, bribes or fines, deter tax evasion, so the taxpayer's optimal disclosure is qualitatively similar with or without corruption.

Following an audit, the auditor will discover all income underreported with probability k_{it} otherwise no evasion will be discovered. The audit probability in province i in time t is denoted as π_{it}. Each taxpayer knows the enforcement

[4] In real world penalties on tax evasion depend on the amount and the type of the evasion. In my empirical analysis below structure of the penalties on tax evasion is irrelevant as long as they are the same across provinces.

variables k_{it}, and π_{it} that characterizes his province. In the manner of Allingham and Sandmo (1972), each taxpayer confronts an audit lottery. He selects a level of income to disclose y^d not exceeding his true income y, in order to maximize expected utility.

$$W(y^d, y, p_{it}) = p_{it}u((1-\tau)y - f\tau(y - y^d)) + [1 - p_{it}]u(y - \tau y^d) \tag{3.1}$$

where $p_{it} \equiv \pi_{it}k_{it}$ denotes the effective probability of detection. Given constant relative risk aversion, it is easily checked that every taxpayer decides to disclose a constant fraction r of his true income, which depends on tax and enforcement parameters p_{it},τ,f. Using the utility function above, the first order condition of maximizing (3.1):

$$fp[(1-\tau)y - f\tau(y - y^d)]^{\alpha-1} = (1-p)[y - \tau y^d]^{\alpha-1} \tag{3.2}$$

re-organizing terms, we get:

$$r(p_{it}, \tau, f) = \frac{y^d}{y} = \frac{(\frac{1-p_{it}}{fp_{it}})^{\frac{1}{\alpha-1}} + f\tau - 1 + \tau}{\tau(\frac{1-p_{it}}{fp_{it}})^{\frac{1}{\alpha-1}} + f\tau} \tag{3.3}$$

Hence total reported taxes in province i in year t equals

$$R_{it} = r(p_{it}, \tau, f)Y_{it}$$

where Y_{it} denotes aggregate reported income of the taxpayer population for unit i in year t. It is well-known that r is increasing in enforcement variables p_{it} and f . Of key interest are the determinants of p_{it}. This depends on (a) the fraction of returns that will be subjected to audit and (b) on the quality of these audits (i.e detection ratio). Consequently, I specify the following equation for reported income:

$$R_{it} = \beta_0 + \beta_1 K_i + \beta_2 T_t + \beta_3 A_{it} + \beta_4 D_{it} + \beta_5 Y_{it} + \varepsilon_{it} \tag{3.4}$$

where K_i denotes a vector of variables specific to each province, T_t is a year dummy representing effects of shifts in tax policy, A_{it} is the probability of an audit, D_{it} is the probability of detecting the tax evasion given that the taxpayer is audited, Y_{it} is the income level, and ε_{it} is a disturbance term picking up the effects of location specific shocks. I use education level, unemployment level, and percentage of individuals without health insurance as province specific variables. Equation(3.4) corresponds to following regression equations.

$$\begin{aligned} RI_{it} = \beta_0 + \beta_1 Unemp_{it} + \beta_2 Educ_{it} + \beta_3 Unins_{it} \\ + \beta_4 Audit_{it} + \beta_5 Detect_{it} + \beta_6 Income_{it} + \beta_7 Year_t + \varepsilon_{it} \end{aligned} \tag{3.5}$$

$$\begin{aligned} RTL_{it} = \delta_0 + \delta_1 Unemp_{it} + \delta_2 Educ_{it} + \delta_3 Unins_{it} \\ + \delta_4 Audit_{it} + \delta_5 Detect_{it} + \delta_6 Income_{it} + \delta_7 Year_{t+} \varepsilon_{it} \end{aligned} \tag{3.6}$$

Table 1
Variable Definitions and Sources[1]

Return [2]	number of income tax returns filed
RI [2]	aggregate reported individual income divided by the number of individual tax return filed, inflation adjusted, in thousand Turkish Liras[4]
RTL [2]	aggregate reported tax lability divided by the number of individual tax return filed, inflation adjusted, in thousand Turkish Liras
Audit [2]	aggregate number of individual income tax returns examined divided by total individual income tax returns filed-the individual audit rate.
Negot [2]	number of negotiations between taxpayer who caught evading tax and tax office
Unemp [3]	the unemployment rate
Detect [2]	total number of negotiations divided by the total number of audits -individual detection rate
Worker [2]	number of tax office workers divided by the total returns filed
Educ [3]	percentage of working population with at least high school education
Unins [3]	percentage of individuals who do not have health insurance
Income [3]	Income per capita, inflation adjusted, in thousand Turkish Liras

[1] All the variables are at the province level.
[2] Data is taken from the Presidency of Tax Administration of Turkey.
[3] Data is taken from the household budget survey.
[4] 1 Turkish Lira is approximately equal to .7 U.S. dollars.

Table 2 : Descriptive Statistics[1]

Variable	Mean	Std. Dev	Min	Max	Number of Obs.
Return	14706	1113	924	62840	400
RI	4.47	1.64	.26	9.06	400
RTL	1.09	.413	.07	2.57	400
Audit	.03	.03	.002	.22	320
Negot	567	624	15	3348	320
Unemp	.09	.03	.04	.17	400
Detect	.50	.36	.05	.91	320
Worker	.02	.01	.001	.09	320
Educ	.23	.08	.1	.53	400
Unins	.30	.06	.16	.75	400
Income	7.71	1.63	.63	14.40	400

[1] The data for *Return*, *RI*, *RTL* , *Unemp*, *Educ*, *Unins* and *Income* is available from 2003 through 2007. For *Audit*, *Negot*, *Detect* and *Worker* the data is available from 2004 through 2007.

My choice of independent variables for the "reporting effect" equation is motivated by two considerations: the size of the tax base and the compliance behavior of the taxpayers. Variables which are primarily related to the tax base are income, unemployment, and percentage of non-insured individuals. Variables that are related to the compliance behavior of the taxpayers include education, audit, and detection rate. Table 1 presents the description and sources of variables that I will be using in my estimations. Descriptive statistics are presented in Table 2.

My expectation regarding the effect of these variables on reported income per return (RI) and reported tax liability per return (RTL) are based on the theoretical model that I present above as well as the previous studies on tax compliance[5]. In

[5] see Beron, Tauchen, and Witte(1992) for the effect of socioeconomics variables on compliance.

general, higher income taxpayers have increased opportunities to evade, but there is a strong direct relationship between real income per capita and RI or RTL. In fact, the latter effect should be quite large, leading to a positive coefficient on income in both regression equations. Provinces with a higher unemployment ratio ($Unemp$) may have unsound economies and thus yield lower RI and RTL. This effect is reinforced if unemployment is associated with underground economy and thus produces non-compliance. On the other hand, if most unemployed taxpayers have relatively low income, then RI and RTL should rise as a portion of the lower tail of the distribution of income is eliminated. To the extent this effect is dominated by the previous effect, I expect a negative coefficient on $Unemp$. Individuals who work in underground economy are less likely to have health insurance. The higher the percentage of individuals without health insurance($Unins$) in a province, the greater is the underground economy will be in that province. Thus, I expect $Unins$ to effect RI and RTL negatively.

Variables that are primarily related to the compliance behavior of the taxpayers include one variable which reflect opportunities to evade and two variables which reflect tax authority enforcement activities. The percent of the adult population with at least a high school education is thought to be positively related to tax noncompliance, presumably because more educated individuals are better able to play the the "tax lottery". Thus, with respect to RI and RTL, I expect a positive coefficient on $EDUC$. Finally, although I expect increases in the audit rate($AUDIT$) to increase taxpayer compliance and thus RI and RTL, audit rates presumably respond to compliance level, so I cannot treat audit rates as an exogenous factor. My model allows for endogeneity of $AUDIT$. Federal Tax Authority might be assigning more auditors to the provinces where tax evasion is more common. This causes more tax returns to be audited in provinces with higher tax evasion rate. In this case, correlation between audit and the unobservable will lead to inconsistent estimates of the parameters using ordinary least squares estimation. Consistent estimation then requires the use of an "instrument", which is correlated with audit rates but not with the compliance rate. I use province level tax office workers per return($WORKER$) as instrument for $AUDIT$. In choosing this variable as an "instrument", two criteria must be considered. First, changes in province level tax office workers per return should systematically affect the audit schedule. The correlation between those two is .62, which implies a positive correlation between $WORKER$ and $AUDIT$. Second, province level workers per return should not be causally linked with compliance levels. It is very unlikely that taxpayers base their decisions on the province level number of tax office workers. Tax authorities determine the number of tax office workers in each province mainly based on the population of the province. Thus, it is reasonable to use $WORKER$ as an instrument for $AUDIT$.

Another important variable which is related with compliance behavior in equations 3.5 and 3.6, is the variable $DETECT$. Measure of detection rate should be measured as the ratio of the number of taxpayers who caught evading to the number of taxpayers who were audited. However, I do not have the data for the number of taxpayers who caught evading tax. Instead, I use data from negotiations between the taxpayer and the tax office after the taxpayer is caught evading. This is justified if the percent of caught taxpayers who chooses to negotiate does not vary between provinces. Alternatively, if the majority of the caught taxpayers choose to negotiate instead of just paying the fine or going to court, the number of negotiation is a good approximation for the number of taxpayers who caught. The annual report of Presidency of Revenue Administration states that over 85% of the taxpayers who caught evading tax requests a negotiation with the tax office[6]. Therefore, using the number of negotiations as a proxy for the number of taxpayers who caught evading tax is reasonable. Finally, I measure the detection rate($DETECT$) as the ratio of the number of negotiations to the number of audits. As the theory suggests, we expect detection rate to have a positive impact on volunteer compliance.

Whether audit rates should be treated as endogenous is ultimately an empirical issue, but the question is amenable to a formal specification test due to Hausman(1978). Hausman's method includes as an additional explanatory variable the predicted value of $AUDIT$ derived from a reduced form equation in which independent variables include those specified in equations 3.5 and 3.6 as well as the instruments. Hausman shows that endogeneity of $AUDIT$ is given by testing the significance of the additional explanatory variable. To form a predicted value of $AUDIT$, I estimate the reduced form equation:

$$\begin{aligned} Audit_{it} = \gamma_0 + \gamma_1 Unemp_{it} + \gamma_2 Educ_{it} + \gamma_3 Year_t \\ + \gamma_4 Income_{it} + \gamma_5 Detect_{it} + \gamma_6 WORKER + \varepsilon_{it} \end{aligned} \tag{3.7}$$

This equation contains the maintained exogenous variables $Unemp$, $Educ$, $region$, $Detect$, $Income$, and $Year$. It also includes the instrumental variable $WORKER$.

[6] www.gib.gov.tr/fileadmin/user_upload/yayinlar/2006_Faaliyet_Raporu.pdf

The results of the OLS estimates of the equation 3.7 are presented in Table 4. The Hausman statistics for the endogeneity of $AUDIT$ corresponds to a t-test for the significance of the coefficient on the predicted value of $AUDIT$, which is obtained from equation 3.7, in equations 3.5 and 3.6. The regressions for testing the endogeneity $AUDIT$ are presented in Table 3. In both regressions $AUDIT$ is found to be endogenous because coefficients of $AUDIT$ and $PAUDIT$ are significant.

3.3.1.1 Results

Table 4 contains results of the two-stage least squares estimation for the reported income (RI) and reported tax liability (RTL). Note first that the model explains much of the variation in RI and RTL. R^2 is .54 for RI and .56 for RTL. As might be expected, the coefficients on income are by far the most significant of the estimated coefficients in the RI and RTL equations. The coefficient on income in RI is .47, suggesting that one Turkish Lira increase in income will result in .47 Turkish Lira increase in reported income. The difference can emerge because of the failures to fully report income to tax office. Alternatively, the difference can partly be explained by the underground economy. Some individuals in the household survey might be revealing their income but may not be filing a tax return. Overall, the coefficient of the income and its statistical significance suggest that my income measure from Household Survey is a good proxy for real income level of the individuals. The coefficient on income in the RTL equation provide an estimate of the marginal tax rate on total income (income before exclusions and deductions by the tax code).

The coefficient of income in the RTL equation is .13, implying that one Turkish Lira increase in income will cause Tax Liability to increase .13 Turkish Lira. Marginal tax rates in Turkey start from 15% for the lowest income bracket and goes up to 20%, 27% and 35% for the highest income brackets. Considering that the majority of the taxpayers fall into the low marginal tax rate brackets in Turkey, the existence of tax evasion and underground economy, the marginal tax rates implied by the income coefficient is reasonable.

I find that increasing the odds of an audit significantly increases reported income and reported tax liability. It is not surprising that the probability of an audit is significant at 1% when we consider the data characteristic. It is important to remember that data is composed of tax returns of individuals whose income is not from wages and salaries. For these individuals, it is easier to hide their income, and previous studies find self employed taxpayers are more likely to evade compared to taxpayers whose income is only from wages and salaries.[7] Coefficients of the *Audit* in both regressions imply that elasticities for RI and RTL with respect to audit are .18 and .15 respectively.[8] These elasticities imply that a 1% increase in audit coverage would lead to approximately a 16.5 million Turkish Lira increase in RI and a 3.8 million Turkish Lira increase in RTL. The finding that elasticity for RI with respect to *Audit* is slightly greater than elasticity for RTL with respect to *Audit* is in contrast with the findings of Beron, Tauchen, and Witte (1992). Beron et al.

[7]See Slemrod(2007) for further discussion on tax compliance od self employed taxpayers.

[8]The elasticities are calculated at the mean values of reported income, reported tax liability and audit rate. Elasticity of RI with respect to $Audit$ is $27 \times \frac{.03}{4.47} = .18$. Elasticity of RTL with respect to $Audit$ is $5.42 \times \frac{.03}{1.09} = .15$

find elasticity of reported income with respect to audit is smaller than the elasticity of reported tax liability. They support their finding with the IRS's belief that its auditors are better able to find over-reported substraction than underreported income. Thus, Beron et al. conclude that audits are more effective in finding over-deductions in tax returns rather than finding underreported income. The income tax code in Turkey is not as complicated as in the U.S. Also, there are only a limited number of items that can be deducted from taxable income which decreases over-deduction opportunity considerably.[9] This suggests that the deterrent effect of audits should not be significantly different for reported income and tax liability. In fact, the elasticities that I calculate for RI and RTL with respect to audit are not statistically different than each other. The other variable in the regression equations that comes from the structural model is detection rate (*Detect*). In Table 3, it is seen that detection rate significantly increases RI and RTL. Coefficients of *Detect* imply that elasticities for RI and RTL with respect to detection rate are .04 and .05 respectively. Comparing the effect of audits and detection rate on RI and RTL, we see that the audit rate is more effective in increasing RI and RTL than the detection rate. There are several explanations for this. First, generally the audit rate is floating around 3% while the detection rate is around 50%. If the audit rate and detection rate has a decreasing marginal effect on RI and RTL, then the elasticity of audit will be greater than the elasticity of detection since the average audit rate is much lower than the average detection rate.

[9]There is only one type income tax return form and deductions can be made for education, health and insurance expenses as well as the donations made to non-profit organizations.

Table 3: Endogeneity of Audit

	Dependent Variable	
	RI	RTL
Audit	9.64*	2.04*
	(1.75)	(2.03)
Paudit[1]	10.1*	2.01*
	(1.87)	(2.53)
Income	.48**	.13**
	(4.25)	(3.68)
Educ	−3.53*	−.50
	(1.73)	(.88)
Unemp	−.10*	−.02*
	(1.87)	(2.07)
Unins	−1.57	−.40
	(1.14)	(1.13)
N	320	320
R^2	.52	.59

[1] Paudit is obtained from the reduced form regression.
t statistics are in parenthesis.
* statistically significant at 10%
** statistically significant at 1%

Second, since the detection rate is more private information compared to audit rate, some taxpayers may not take the detection rate into account while making their reporting decision. This causes audits to be more effective in increasing RI and RTL. Finally, detection rate may be prone to endogeneity problem and the results can be downward biased. If the detection rate is correlated with unobservables like audit rate, the coefficient of *Detect* will be biased.

The coefficient of unemployment variable is negative and significant at the 1% level in both regressions. This could be because provinces with higher unemployment rates have unstable economies, and this may cause the tax base to be less. The effect will be more if unemployment is associated with underground economy. The effect of education on compliance is generally found to be negative in some of the previous works, while it is found to be positive in some others.[10] Jackson and Milliron (1986) suggest that the more educated may be less compliant because they better understand the opportunities for evasion and are more willing to play the audit lottery than are the less educated. However, Dubin and Wilde (1988) find that the educated are more compliant with the tax laws. I find a negative effect of education on compliance. Education is significant for RI equation, but it is not significant for RTL equation. Finally, the percentage of individuals who do not have any health insurance (*Unins*) has insignificant effect on compliance. I used *Unins* as a proxy for underground economy, since most of the individuals who work in underground economy do not have any health insurance. The *Unemp* variable can also be associated with underground economy and serve as a proxy for underground economy.

[10] Beron, Tauchen, and Witte(1992) and Dubin and Wilde(1988) find education is negatively related with compliance.

Table 4: Effect of Audits on Compliance[1]

	IV Regression		Reduced Form for Audit
	RI	RTL	Audit
Audit	27* (2.42)	5.42* (2.48)	
Detect	.43* (2.11)	.13* (2.23)	.013* (1.73)
Income	.47** (3.34)	.13** (3.67)	.004* (2.11)
Educ	−3.64* (1.80)	−.26 .93	.05 (.85)
Unemp	−.11* 2.03	−.03* (2.15)	.0007 1.24
Unins	−.41 (1.14)	−1.70 (1.20)	.025 (1.48)
Year05	.15 (1.23)	.07* (2.15)	−.005* (1.87)
Year06	.04 (.34)	.008 (.21)	.004 (1.30)
Year07	.24 (1.32)	−.06 (1.22)	.002 (.70)
Worker			.14* (2.01)
N	320	320	320
R^2	.54	.56	.61

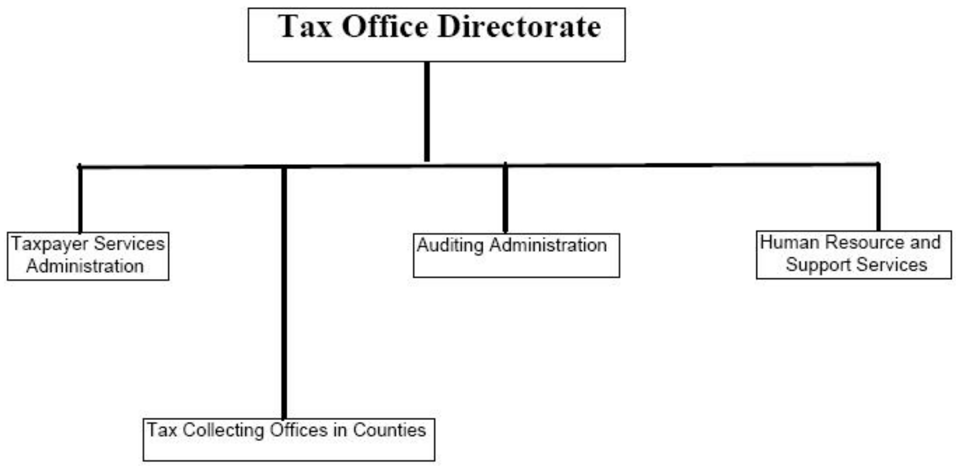
[1] IV Estimation. Observations are clustered for each province.
t statistics in parenthesis.
* statistically significant at 10%
** statistically significant at 1%

3.4 Tax Administration Reform

In this section, I analyze the effect of establishing Tax Office Directorates (T.O.D.) in 29 provinces on taxpayer compliance. The reform in the tax administration was realized both at the federal level and at the local level. At the federal level, the main institutional and organizational change was the establishment of a semi-autonomous tax administration operating on a functional basis. The Presidency of Revenue Administration plans to carry out their tax responsibilities by simplifying the system and by providing necessary assistance to the taxpayers in order to minimize the burden on Turkish citizens. At the local level, the T.O.D. was established to identify potential taxpayers and register them with the tax office, enforce and improve tax compliance, inform taxpayers about their responsibilities and rights, collect data, and audit taxpayers. The T.O.D. also supervises, and provides coordination between tax collecting offices in counties. Before the establishment of T.O.D.s, there was no organizational connection or cooperation between the tax collecting offices in different counties. One branch of the T.O.D. is responsible for helping taxpayers in filing their returns. This branch also has a call center to answer taxpayers' questions. Another branch of the T.O.D. is an auditing unit which is responsible for collecting data on the results of the audits and using the data to increase audit quality. Finally, the last branch of the T.O.D. is responsible for educating the auditors and other tax office workers. A representative organization scheme of the T.O.D.s is provided in Figure 2.

The duties of the T.O.D. imply that it aims to increase tax compliance in two ways. First, by increasing taxpayer help services and informing taxpayers about their responsibilities and rights, the T.O.D.s intend to increase voluntary tax compliance. Second, T.O.D.s plan to increase enforcement and its quality. By collecting data and information on taxpayers T.O.D.s strive to increase the quality of audits. The increased enforcement (higher audit and detection rates) increases

Figure 3.2: Tax Office Directorate



compliance as the theory and my findings in part 1 suggest. The question that we want to answer at this point is whether establishing T.O.D. in 29 provinces increased compliance compared to provinces where no T.O.D. was established. I use 52 provinces that have no T.O.D. as a control group and 29 provinces that have T.O.D. as a treatment group. A dif-in-dif methodology is employed to isolate the effect of establishing a T.O.D. on tax compliance. The provinces in the treatment group experienced the change in their tax administration in May 2005. The selection process for the provinces where T.O.D.s were established is not random. This would have been a problem for a controlled experiment if the selection process was based on the compliance results of the provinces. However, the federal tax authority decided where to establish a T.O.D. according to the number of tax returns of the provinces rather than the compliance results of provinces. In Figure 3, we see that the selection process is generally based on the population rather than on the compliance of the province. All provinces with a T.O.D. have greater number of tax returns than non-T.O.D. provinces. However, reported income per return seems to have no direct relationship with existence of a T.O.D. in a province. For pre-reform compliance, I use 2004 and 2003 returns. For post-reform compliance, I use 2006 and 2007 returns. If establishing T.O.D.s has any effect on compliance, 2006 and 2007 tax returns should reflect that effect. I run the following difference in difference regressions to estimate the treatment effect.

$$\log(RI_{it}) = \beta_0 + \beta_1 treatment + \beta_2 reform + \beta_3 reform^{*} treatment + \varepsilon_{it} \quad (3.8)$$

$$\log(RTL_{it}) = \beta_0 + \beta_1 treatment + \beta_2 reform + \beta_3 reform^{*} treatment + \varepsilon_{it} \quad (3.9)$$

where $treatment$ is the dummy variable for the treatment group- if the province has a T.O.D., $treatment$ is 1, otherwise it is 0. The variable $reform$ is the other dummy for post-reform period. If the observation belongs to the post-reform period (2006 or 2007), then $reform$ is 1. If the observation belongs to pre-reform period (2003 or 2004), then $reform$ is 0. I use the logs for reported income and tax lability because it allows me to see the effects as a percentage increase rather than levels. Since the treatment group is generally composed of large and developed provinces, mean of reported income and tax liability is higher for the treatment group compared to control group. In Table 5, I present mean values of reported income, tax lability, number of tax returns, and income for control and treatment groups.

The variable of interest is β_3 in regression equation 3.8. Difference in difference regression estimates in Table 6 suggest that establishing T.O.D.s had no significant effect on neither on RI nor RTL. As seen in the first two columns of Table 6, coefficient of $reform^{*}treatment$ is far from being significant. A possible explanation for this is the following. Theory suggests that increasing audit and detection rates should increase compliance. My findings in section 2 also supports this argument. Therefore, either T.O.D.s were not successful in increasing the detection rate, or provinces in control group increased the detection rate along with the provinces in the treatment group. Using $DETECT$ as a measure for detection rate, as I used in section 2, I can check whether the detection rate in the treatment group has increased significantly after reform compared to the control group. I run the following regression to see the effect of establishing T.O.D.s on the detection rate:

$$DETECT_{it} = \alpha_0 + \alpha_1 treatment + \alpha_2 reform + \alpha_3 reform^{*}treatment + \varepsilon_{it} \quad (3.10)$$

Again, in the third and fourth column of Table 6, we see that coefficient of $reform^{*}treatment$ is close to zero, which means establishing T.O.D.s did not significantly affect the detection rate or audit rate. It is possible that a two-year period after the establishment of T.O.D.s was not long enough to implement the necessary changes in auditing strategies. Another possibility is that there is a problem with the measure of detection. Given that taxable income per return and tax lability per return did not increase significantly, as we see in the regression results of equation 3.8, it is more likely that T.O.D.s were not successful in strategically auditing taxpayers.

The other goals of T.O.D.s are to increase taxpayer services (i.e helping them prepare their tax returns) and to audit non-filing individuals who earn income. The latter goal can also be referred to as controlling the underground economy. In order to do that, T.O.D.s audit businesses and individuals they think are earning income but not filing a tax return. I was unable to get data for this kind of auditing.[11] In these types of audits, if individuals are found to be earning income but not filing a tax return, they have to register themselves to the tax office and pay a fine. Unlike the theoretical literature on tax evasion, the failure of taxpayers who have filed returns to report all income, there is not much theoretical literature on non-filers. One of the few theoretical works is a model due to Graetz and Wilde (1990) dealing with the decision by non-filers to participate in tax amnesties. In their model, however, taxpayers who file returns are assumed to report honestly. Next, I analyze the effect of establishing T.O.D.s on the number of tax returns. The dif-in-dif regression for the number of tax returns is the following:

$$\log(return_{it}) = \lambda_0 + \lambda_1 treatment + \lambda_2 reform + \lambda_3 reform^{*} treatment + \varepsilon_{it}$$

where $log(retrurn_{it})$ is the log of number of tax returns. We see in the last column

[11] I was unable to obtain data of this type of audits. The Federal Tax Authority in Turkey has such data but unfortunately I couldn't get it so far.

of Table 6 that the coefficient for *reform**treatment* is positive and significant. Therefore, I conclude that establishing T.O.D.s had a positive effect on the number of tax returns.[12] In other words, T.O.D.s were successful in finding non-filers and registering them as a taxpayer. This result is not surprising when we think of the size of the underground economy in Turkey. Even a small effort to increase the number of filers pays off because the size of the underground economy is huge compared to developed countries. The lack of data on efforts to increase the number of tax returns prevents us from comparing the effects of regular tax return audits and non-filer audits.

[12] One might be suspicious about the relationship between number of tax returns and reported income or tax liability. Our compliance variables RI and RTL are reported income and tax liability per return. Having more individuals filing a tax return will not effect these variables as long as the mean values of RI and RTL for the new filers are close to the mean values of RI and RTL for the existing filers.

Table 5: Treatment and Control group sample selection[1]

	Mean Reported Income	Mean Tax Lability	Mean number of tax return	Mean Income	Number of observation
All Sample	4.44	1.06	14645	7.69	320
Control Group	3.84	.90	5666	7.21	208
Treatment Group	5.58	1.37	31321	8.59	112
Difference[2](Treatment-Control)	1.74**	.47**	25655**	1.37**	
	(8.9)	(10.3)	(14.5)	(6.3)	

[1] data is from years 2003, 2004, 2006 and 2007. 2003 and 2004 are pre-reform period, while 2006 and 2007 are post-reform period.
[2] t statistics are in parenthesis.
** statistically significant at 1%.

Table 6. Dif-in-Dif Regressions[1]

	Dependent Variable				
	log(RI)	log(RTL)	DETECT	Audit	log(return)
Treatment	.36**	.39**	−.36*	−.02**	1.48**
	(4.77)	(5.00)	(1.70)	(2.72)	(11.2)
Reform	.37**	.21**	−.17	.01	.02
	(11.5)	(6.57)	(.40)	(.43)	(1.29)
Treatment*Reform	.03	.03	−.08	.01	.08**
	(.85)	(.79)	(.19)	(1.55)	(2.59)
Constant	1.07	−.28	1.05	.02	8.44
	(17.1)	(4.60)	(6.09)	(8.55)	(90)
R^2	.35	.27	.16	.33	.57
N	320	240	240	320	320

[1] Observations are clustered for each province.
t statistics are in parenthesis.
* statistically significant at 10%
** statistically significant at 1%

3.5 Conclusion

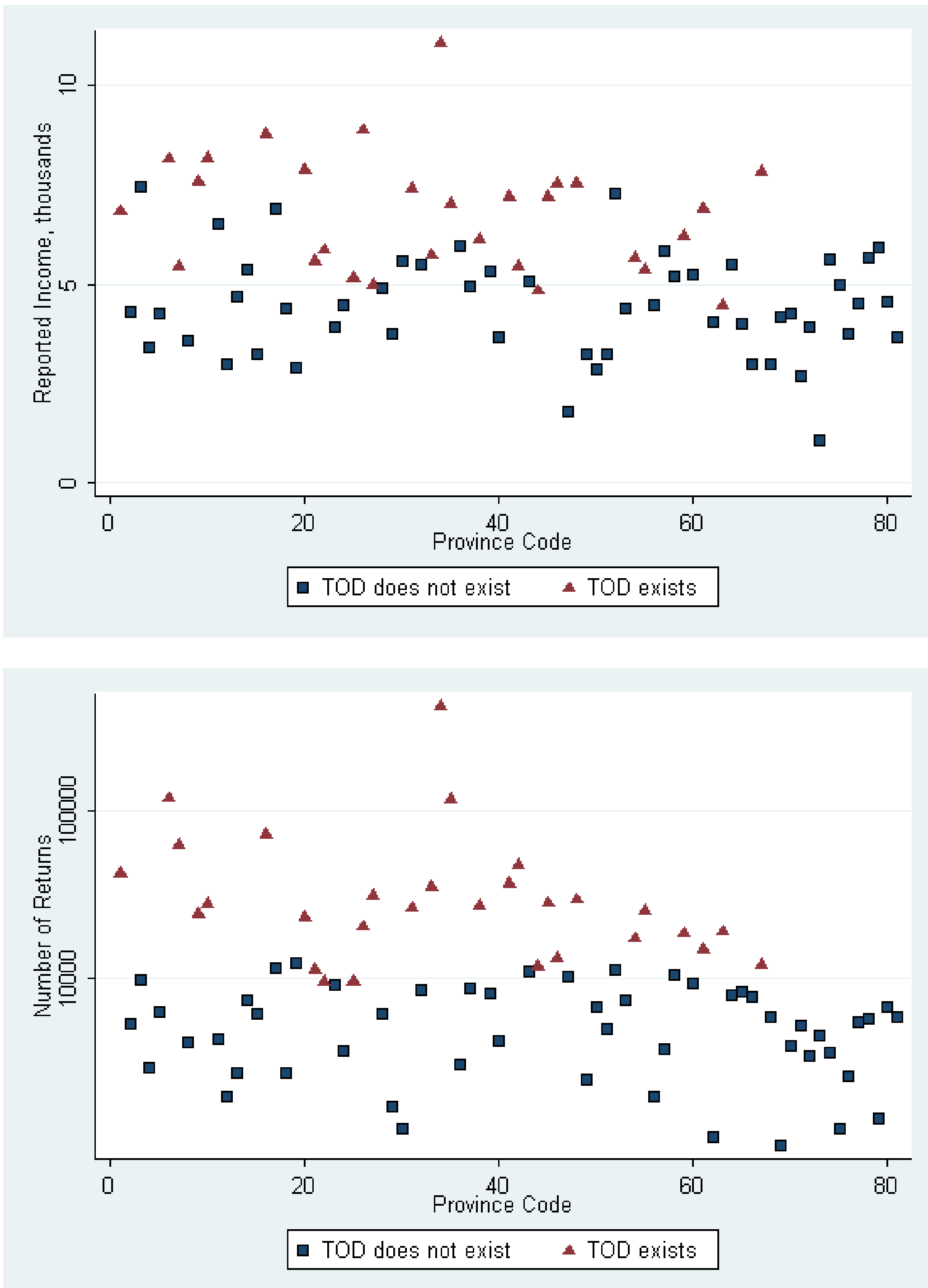
Empirical studies on tax evasion are limited due to data availability. Many of these studies use data from developed countries, and there are only a few empirical analyses of tax evasion in developing countries. Many developing countries suffer from a large underground economy, bureaucratic inefficiency, and economic instability. Thus, an analysis of tax evasion for these countries might yield different results than the studies of developed countries. I use province level income tax return data from Turkey to estimate the effect of audits and tax administration reform on tax compliance. My measure of compliance is reported income and reported tax liability. They are not perfect measures of compliance; however, considering the difficulty and complexity of getting direct measures for compliance or evasion, reported income and tax liability can be a good proxy for compliance as long as the income level is controlled in estimation. Controlling for the income level and allowing for the endogeneity of audits, my analysis of the Turkish panel data set has yielded a number of results.

First, audits have a strong positive effect on reported income and tax liability. The data set I use is comprised of self employed taxpayers who generally have more opportunities to evade. Thus the coefficients audits that I find are larger compared to previous studies that use data sets including wage and salary earners. Furthermore, the effectiveness of audits is the same for reported income and tax liability. The reason for this might be that the income tax system in Turkey is not as complex as the income tax system in the U.S.A, and there are not many opportunities to make deductions. Or, the reason might be that the detection rate is endogenous, and this may cause the coefficients to be biased. The latter possibility can be tested if an appropriate instrumental variable is found for the detection rate. I also find that the unemployment rate, which tends to have no direct impact on auditing, has dramatic effects on reported income and reported tax. This is generally because unemployment is associated with a low tax base.

Second, the reform in the tax administration (i.e establishing T.O.D.s) had no significant effect on compliance. Neither the detection rate of evasion nor the audit rate has increased during the post-reform period. However, the number of tax returns increased considerably during the post-reform period. This suggests that tax reform had an effect at the extensive margin rather than at the intensive margin. In other words, existing taxpayers did not change their compliance behavior, yet more individuals started to file tax returns. Tanzi and Pellechio (1995) states that strengthening if tax administration will not result in higher revenue in the short run. The two year period after the reform can be too short to see the positive effects of the reform on compliance.

In developing countries where unregistered economy is common, the tax revenue gain from efforts to increase the number of tax filers can be very large. A natural question that can be asked is whether tax return audits or efforts to increase the number of tax filers has a larger impact on tax revenues. In order to compare those two effects, we would need data on the efforts to increase the tax filing rate in addition to audit data.

Figure 3.3: Tax Office Directorate Selection Process



-Tax Authorities chose provinces to establish a Tax Office Directorate according to the number of tax returns rather than the compliance levels.

Appendix

Appendix 1

Chapter 2 Appendix

1.1 Expenditure function approach

From the maximization problem of the individual taxpayer, we can figure out demand functions for C_1 and C_2, supply function for L, and tax evaded E as the optimal choices. Since we derive the first order conditions in eqs. (2.4) - (2.7) in section 3 and reformulate the two budget constraints with the virtual income Z (regarded as exogenously given) in section 4, the optimal choice functions C_1, C_2, L and E can have as their arguments the net wage rate $(1-m)w$, audit rate p, penalty rate π, publicly supplied nonmarket good G, and transfer Z. Thus, the indirect expected utility function $\bar{U}^*$ can be constructed as $\bar{U}^* = \bar{U}^*\left((1-m)\,w, p, \pi, G, Z\right) \equiv (1-p)U(C_1(\cdot), V(\cdot), G) + pU(C_2(\cdot), V(\cdot), G)$ where the dot represents the vector of the arguments mentioned above. By using the Envelope Theorem, we have the partial derivatives of $\bar{U}^*$ with respect to each of the parameters $(1-m)w$, p, π, and Z as follows:

$$\bar{U}^*_{(1-m)w} = (\lambda_1 + \lambda_2)\,L, \tag{1.1}$$

$$\bar{U}^*_p = U(C_2, V, G) - U(C_1, V, G) \leq 0, \tag{1.2}$$

$$\bar{U}^*_\pi = -\lambda_2 E, \tag{1.3}$$

$$\bar{U}^*_Z = \lambda_1 + \lambda_2. \tag{1.4}$$

In order to develop the relationship between the uncompensated and compensated elasticity of labor supply with respect to each of the net wage rate $(1-m)w$, the audit rate p and fine rate θ, we exploit the expenditure function approach. Now, the uncompensated and compensated labor supply are equal at the optimum: $L\left((1-m)w, p, \pi, G, Z\left((1-m)w, p, \pi, \bar{U}^*\right)\right) = L^c\left((1-m)w, p, \pi, G, \bar{U}^*\right)$. Partially differentiate this identity to get three Slutsky equations that are associated with the net wage rate $(1-m)w$, the probability rate p and the penalty rate π:

$$L_{(1-m)w} + L_Z Z_{(1-m)w} = L^c_{(1-m)w}, \tag{1.5}$$

$$L_p + L_Z Z_p = L^c_p, \tag{1.6}$$

$$L_\pi + L_Z Z_\pi = L^c_\pi. \tag{1.7}$$

Since Z can be found by inverting the indirect utility function $\bar{U}^*$, it is easy to derive the partial derivatives of the virtual income Z from eqs. (1.1) - (1.4) together with eq. (2.6) as follows:

$$Z_{(1-m)w} = -\frac{\bar{U}^*_{(1-m)w}}{\bar{U}^*_Z} = -L, \tag{1.8}$$

$$Z_p = -\frac{\bar{U}^*_p}{\bar{U}^*_Z} = \frac{E}{p}, \tag{1.9}$$

$$Z_\pi = -\frac{\bar{U}^*_\pi}{\bar{U}^*_Z} = \frac{E}{\theta}. \tag{1.10}$$

The first-order Taylor expansion is used in order to approximate the marginal utility function $U\left(C_1, V, G\right)$ to $U\left(C_2, V, G\right) + U_C\left(C_2, V, G\right)\left(C_1 - C_2\right)$ in eq. (1.9). Insert eqs. (1.8) - (1.10) into three Slutsky equations above, and then multiply the results by $\left(1-m\right)w/L$, P/L and θ/L respectively to get three relationship between the uncompensated and compensated elasticity of labor supply with respect to the net wage, audit, and fine rate:

$$\eta - (1 - m)\, wL_Z = \eta^c, \tag{1.11}$$

$$\varepsilon_p + \frac{E}{L} L_Z = \varepsilon_p^c, \tag{1.12}$$

$$\varepsilon_\theta + \frac{E}{L} L_Z = \varepsilon_\theta^c. \tag{1.13}$$

In eqs. (1.11) - (1.13), the superscript c indicates "compensated," while no superscript implies "uncompensated." The parameters η, ε_p, and ε_θ denote the elasticity of labor supply with respect to the net wage, audit, and fine rate respectively. Furthermore, combining eqs. (1.11) - (1.13) together yields

$$L_Z = -\frac{\eta^c - \eta}{(1 - m)\, w} = \left(\varepsilon_p^c - \varepsilon_p\right) \frac{L}{E} = \left(\varepsilon_\theta^c - \varepsilon_\theta\right) \frac{L}{E}$$

which gives

$$\varphi \equiv \frac{E}{wL} = -\frac{(1 - m)\left(\varepsilon_p^c - \varepsilon_p\right)}{\eta^c - \eta} = -\frac{(1 - m)\left(\varepsilon_\theta^c - \varepsilon_\theta\right)}{\eta^c - \eta} > 0.$$

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This dissertation was typeset with LaTeX† by the author.

†LaTeX is a document preparation system developed by Leslie Lamport as a special version of Donald Knuth's TeX Program.